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Fireworks 58

To supply the staggering volume of effects required for *Independence Day*, director Roland Emmerich and producer Dean Devlin chose not to engage a major effects facility, electing instead to build an in-house miniatures and pyrotechnic unit, coupled with an independent digital effects unit, dedicated solely to the production. *Article by Tim Prokop.*

Cruising the Digital Backlot 90

The action finale of *Mission: Impossible* - created by Industrial Light & Magic - entailed placing a computer generated train and helicopter into digitally altered or created backgrounds, enhanced with elaborate miniature work and pyrotechnics. *Article by Mark Cotta Vaz.*

Split Personalities 106

For *Multiplicity* - a comedy about a man who hopes to find time for himself by undergoing a cloning procedure - director Harold Ramis engaged Boss Film Studios to produce four distinct versions of actor Michael Keaton, all of whom had to interact verbally and physically during the course of the film. *Article by Janine Pourroy.*

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COVER - Alien invaders destroy the White House in *Independence Day*.

THE NUTTY PROFESSOR PLEASEINGLY KLUMP

article by Jody Duncan

In the early sixties, Jerry Lewis directed and starred in a manic comedy about a socially inept professor who transforms into a cocky Lothario named Buddy Love. Thirty-some years later, *The Nutty Professor* is still considered by many to be his masterpiece. Considering the film's popularity and Lewis' enduring status as a comedic icon, only an actor with a generous measure of talent and confidence would dare to remake *The Nutty Professor* and step into the role. Endowed with both qualities, Eddie Murphy was not at all daunted by the prospect- and, in fact, the Imagine Entertainment and Universal Pictures remake was his idea, initially submitted to director John Landis.

Produced by Brian Grazer and Russell Simmons, *The Nutty Professor* was directed by Tom Shadyac, who took over when Landis moved on after a month of development. Less broad than the original film, the remake did retain many of the same characters and story elements. In the new version, the professor of the title is Sherman Klump who, at 400-plus pounds, leads a lonely life, despite his fine intellect and good heart. When his scientific research leads to a dramatic fat decrease in a chubby hamster, Sherman ingests the DNA-altering chemicals himself and transforms, temporarily, into the lean, but obnoxiously over-confident, Buddy Love.

With Murphy slated to portray both Buddy Love and Klump- as well as four members of the Klump family and a Richard Simmons-like exercise guru named Lance Perkins- makeup effects would play a dominant role. To design those effects, multiple Academy Award winner Rick Baker was brought onto the project, soon followed by visual effects supervisor Jon Farhat, who coordinated split-screen photography and other effects during production, then designed and oversaw postproduction work at Computer Film Company, Light Matters and Rhythm & Hues.

The first of the film's 150 effects shots comes early, as a laboratory mishap leads to the release of hundreds of research hamsters onto the college campus. While the fat hamster introduced in the lab was an animatronic creation- produced by Rick Baker's crew from a sculpture by Ed Yang- the hamster horde was a combination of real animals, inanimate puppets and CG models, created by Light Matters visual effects supervisor Mat Beck. Even some of the real hamster footage, shot on the set, required digital manipulation. "The real hamsters didn't always run the way Jon Farhat wanted them to," explained Beck, "so we scanned footage of a hamster running on blue fabric, isolating and freezing him in place, then cycling his little legs to create a continuous movement. We wound up with a digital puppet that was based on a real hamster, but could be duplicated and put into plates any way we wanted."

One hamster flies through frame and into a woman's open mouth- a gag complicated by the restrictions imposed on working with live animals. "No hamster was harmed in the making of this movie," Farhat asserted dryly. "We had the American Hamster Association, or some such organization, there to make sure of that; so we were limited in how we could get the shot of the hamster flying across frame. We couldn't strap him to anything, we couldn't brace him to

anything- we couldn't do dick with the hamster. We finally decided to shoot an inanimate hamster puppet against bluescreen and let Mat Beck animate some life into it."



For the remake of *The Nutty Professor*, makeup artist Rick Baker transformed actor Eddie Murphy into 450-pound Sherman Klump, using facial appliances and a lightweight fat suit made of urethane foam.

Called onto the carpet for the rodent debacle is Sherman Klump. Because the transformation of Eddie Murphy into the obese professor was such a key illusion, Rick Baker had been hired during the earliest stages of preproduction, when John Landis was still slated to direct. Baker was a logical choice- not only was his reputation as a makeup artist unsurpassed, he had already built a solid relationship with Eddie Murphy while creating the ingenious makeups for *Coming to America*.

"I thought *The Nutty Professor* was a great project," Baker stated. "At the beginning, Eddie was not only going to be playing this 450-pound man, he was slated to play all the family members, the fitness expert, a nightclub comedian and a clothing salesman." To prepare for the scope of the assignment, Baker and crew began work immediately, taking a lifecast of Murphy and sculpting designs for all the different characters. Even after Landis' departure, Baker continued to refine the Sherman concepts. "We knew that Eddie would still be playing this overweight man, even if other ideas came and went, so we concentrated on that."

At the same time, the makeup team was also developing a fat suit for Sherman. "We cast a fat suit made of foam rubber," Baker explained, "but I ruled that out as too heavy. Eddie was going to be in the suit for seventy days of the shooting schedule, so we had to make it comfortable. We made the lightest suit possible out of urethane foam, covered in spandex." That first suit had to be altered when Tom Shadyac signed on and determined that Sherman should be a much larger man. "We threw out everything and started over, making heavier foam latex appliances and a whole new batch of fat suits. Once we got into production, I realized that Tom had been absolutely right, and that a larger Sherman did work better, visually and dramatically."

The Sherman makeup was not yet completed when a studio executive asked that it be tested on Murphy as soon as possible. "We knocked out a quick fat suit, makeup and a pair of hands for that initial test," Baker recalled. "After we had applied the whole thing to Eddie, we videotaped him as he performed different characterizations and voices. Unlike a lot of actors who are afraid of working in makeup, Eddie likes to become someone else. We ended up with this very funny hour-long tape, and the test was a great success." Although Baker had resisted the spur-of-the-moment test, the tight schedule occasioned by it actually led to a simplification of the makeup. "Normally, I would have done this make-up in a number of pieces. But the test came up so quickly, I decided to make a simple mold and divide the makeup into only two pieces- the left side of his face and the right side, with the seam right down the middle. Each of the big foam



Visual effects supervisor Jon Farhat enlisted three effects firms for the picture, including Rhythm & Hues, which produced a number of surreal morphing scenes.

latex pieces went up under his eyes and around to the back of his head. The two-piece approach worked very nicely, and we went with the same technique for the final makeup.”

A separate piece was required for the bulging area beneath Sherman’s chin, however. The double chin had been sculpted and cast, when shrinkage problems were detected. “It was supposed to come down from the chin and sit on Eddie’s shoulders,” Baker explained, “but the whole piece shrunk up and off his body. Another problem was that the heavy wrinkles we had sculpted into it only looked good when the neck was stationary. They did not move realistically. To solve both problems, we sawed off the head of Eddie’s lifecast, and added about an inch of length to his neck. Then we resculpted the neck piece, with more subtle wrinkles. Since we had added an inch to the neck, there was extra material when we cast the piece, which compressed into natural-looking folds. A liquid-filled bladder inside created the right heaviness and movement.”



For a dream sequence in which Sherman grows to gargantuan proportions, Jim McPherson of the Rick Baker team created an extremely obese makeup for Murphy to wear during greenscreen photography. The footage was composited into live-action plates by Computer Film Company.

One set of makeup appliances, plus backups, was required for each of the seventy Klump shooting days– and with a standard one-in-five success rate in running foam rubber, that translated to between 350 and 400 runs. To meet such a demand, three original molds had to be made so that three sets of appliances could be run at a time. To produce the molds, Mitch Devane had to sculpt Sherman three times, making sure each sculpture matched perfectly.

By the time shooting was scheduled to begin, thirty sets of appliances had been fabricated– an ample head start that was lost when a final test revealed a problem with the foam. “There was a weird skinning effect caused by our use of nonporous molds,” said Baker. “The appliance would look like it had a good skin; but as soon as we applied the pax paint, it would stick to itself. The result was that all thirty of the pieces were no good. Suddenly, instead of having a thirty-day lead, we were starting all over just as filming was about to begin. It was ‘beat the clock’ time; and, at first, we were cutting it really close, finishing up pieces the day before we needed them.” From start to finish, it could take up to two weeks to complete a single set of appliances– one week to get a good run, and another week for meticulous cleanup. “The cleanup on this makeup was especially time consuming because the seam had to be perfect. Carol Koch, our main seamer, did an amazing job. You could get right up to the makeup, and still not see that seam.” Application of the entire Sherman makeup was a three-and-a-half-hour affair, executed by Baker and assistant David Anderson.

In addition to creating the look for Sherman, Baker and his crew designed makeups for five of the other six characters Murphy would portray, including Lance Perkins. “Our main concern with Lance was just making Eddie look like a white guy,” Baker stated. “Because Eddie was only

going to be shooting this character for a day or so, I decided that, even though it would be heavy, we could make a complete foam rubber body for him. We built the thing and tested it on one of the guys in the shop- and it looked like a rubber suit. So we wound up just painting Eddie in pax and making a fairly simple foam rubber mask. The trickiest area was the armpit. White people have different armpit hair than black people; so we had to glue Eddie's own hair down, then apply a hairpiece."

The Klump family members played by Murphy- Grandma, Papa, Mama and brother Ernie- were more prominently featured, specifically in scenes around the family dinner table. Baker's crew had already invested many man-hours in the makeups when Tom Shadyac came on board and promptly announced that the dinner scenes would be cut. "I was stunned," Baker recalled. "I said: 'You might as well rip my heart out, man. You're taking away all the fun stuff!' His thinking was that the family characters would distract from the movie, while I thought Eddie would shine in those scenes. Eventually, Tom did a complete turnaround and put the family scenes back in."



In addition to the Sherman Klump character, Eddie Murphy played four other members of the Klump family. Rick Baker-who created the makeups-studies his work on Mama Klump between takes.

However, in an effort to contain the blossom- ing budget, the studio still wanted the scenes cut. Baker, Shadyac and Murphy vehemently opposed the decision, and immediately set out to reverse it. "We got Eddie out here right away to put the makeups on him and shoot some tests that we could show to the studio," Baker said. "We had just finished the molds on the mother and grandmother; so we did the mother first, with a makeup that was literally fresh out of the mold- in fact, it was our first run of foam rubber." With the Mama makeup applied, Murphy was positioned in front of a video camera and prompted by a single statement from Baker: "Tell me about your son Sherman."

"From that," said Baker, "I got an hour's worth of hysterically funny footage. The next day, we did the same thing with Eddie made up as the grandmother- and I got about two hours' worth of hysterical footage. Tom cut all the best stuff together and presented it to studio executives. When they saw what they would be losing, they agreed the scenes should stay."

With the studio's blessing, Baker continued on the makeups, evolving his designs without input from Eddie Murphy. "Eddie's approach is, 'You give me a face first, and then I'll figure out how to play that character,'" Baker commented. An exception was Grandma Klump, whom Murphy intended to play as a Moms Mabley type of character. Sculpted by Aaron Sims, the final grandma makeup consisted of several foam latex appliances, the application of which was complicated by Murphy's mustache. "As cooperative as he is, Eddie refuses to shave his mustache. I told him that it would save half an hour in the makeup chair- but he still wouldn't shave it. So for Lance Perkins, the grandmother and the mother, we had to apply a special piece over the mustache, trying not to add a lot of bulk."

Mama Klump- Baker's favorite makeup of the show- was sculpted by Matt Rose. Another multiple appliance design, the makeup included a fat suit, complete with breasts. Brother Ernie consisted of body padding and a foam rubber mask. "We had thought about breaking that makeup into pieces," said Baker, "but when the Sherman makeup worked so well, I thought we should try a more mask-like approach first. Except for the mouth area, Eddie's entire head was covered for Ernie." The Papa Klump makeup was similar to Sherman's, with padding, a bald pate, eye balls and eyelids.

With Murphy playing virtually every character at the table, the dinner scenes represented a major portion of the on-set effects effort. An elaborate game plan for their filming was devised by Jon Farhat who, with Shadyac, started by blocking out the scenes with doubles, then videotaping their performances. "We'd shoot these scenes around the dinner table," said Farhat, "each time going for a different character. We'd say, 'Okay, we're shooting for you today, Granny.' They'd all perform the scene, but we would concentrate on Granny- her reactions, who she was looking at when, et cetera. We'd get our two-shots with Granny, shots of her from the length of the table, whatever we needed." Once each character had been covered, the video footage was edited into a final scene. "With the scene cut together, we could determine what Eddie was going to have to do for each character. We could see exactly how many shots each character had, and what that character was doing in each of them."

After the scenes were analyzed, Shadyac and Farhat began filming Murphy in the roles, starting with the character of Papa. In makeup, Murphy was equipped with an earwig so that he could hear the off-camera doubles. To guide his eye-lines, tennis balls were mounted at appropriate heights around the dinner table. "Eddie would perform the whole scene as Papa, playing off the doubles' vocal performances," noted Farhat. "The next day, he would be in Mama makeup, and we'd shoot that character. The audio from Eddie's Papa performance the day before would be replayed- so the only off-camera doubles we needed at that point were the brother and the grandmother. The next day, we'd only need the grandmother double, because Eddie would be playing the brother live, and the recorded dialogue from the previous two days- Papa's and Mama's- would be transmitted into his ear. By the end of the process, Eddie was performing completely against himself, and all the doubles were gone." Portable greenscreens were employed whenever crossovers were required- and video cameras were pointed toward the dining table at all times to ensure that food and dishware remained in position, undisturbed between setups.

Devising the shooting strategy for the family scenes was Farhat's proudest achievement on The Nutty Professor. "Flying ships and explosions are simple- this was challenging," Farhat observed. "The logistics were so harrowing, there was a tremendous amount of planning that had to be done. But once I had designed the procedure, it was like clockwork. It allowed Tom to work on the fly and Eddie to improvise on the set. From my standpoint, the beauty of this show was in being able to shoot Eddie that way."

Computer Film Company was responsible for compositing the dinner sequences and executing the elaborate split-screens. "The split-screens were complicated," remarked Farhat. "They would split down the middle of a china plate, then around a piece of corn. It was more than just

compositing- these shots and others in the movie required a lot of creativity. Janek Sirrs- who supervised CFC's

work- did a wonderful job. Many times, he would be there all night, working to get a shot just right. CFC is the most responsible, most artful company I've ever worked with."

In one of the most challenging of the family shots, Mama pushes open a screen door and walks onto a porch. Behind her, Sherman catches the door, then releases it as he continues through the doorway. A swinging door frame- with its screen removed- was set up on a foyer set, with a greenscreen positioned on the other side, where the porch would be. "We had Mama walk through first," Farhat explained, "opening the door, then letting it go. Because Sherman was supposedly catching it at that point, we couldn't have the door slam shut, so I held onto a rod off-camera that allowed me to catch it. I pulled on it as if Sherman had opened the door, then let it slam. We encoded the door movement and camera movement so that we could use motion control for the 'B' side. Four days later, we filmed the Sherman side- but because we now had motion control, the camera moved by itself, and the door opened, caught itself and closed by itself. Eddie just had to make sure he was pushing on it and catching it and releasing it at the right times to correspond to the motion control moves." To complete the shot, a door screen was photographed separately, then composited into the frame by CFC.

The family members were also featured in the Alumni Ball sequence that ends the film, with some twenty composites executed by Light Matters. At one point in the proceedings, Papa helps Mama up from the floor- a shot that had been conceived at the last minute, requiring Jon Farhat to generate elements as quickly as possible. "Digital supervisor Edson Williams did some fine-tuning on those shots to make them sync up," Mat Beck remarked. "We had to adjust arms and shoulders, tweak elbows, line up hands. We even color-corrected hands from another person in the scene and fit them in."

In addition to makeup and split-screen work, The Nutty Professor boasted 2-D computer animation, used for shots of Sherman transforming into Buddy Love, and vice versa. Rhythm & Hues completed forty such shots, extending transitional appliance pieces provided by Rick Baker. "We needed practical effects to initiate the morphing shots," noted Farhat, "so that we could match skin tones and clothing textures. By using practical devices to start the effect, we didn't have to deal with CG clothes and all the other problems of morphing from a thin character to a fat one." The most complex morphing effects were featured at the Alumni Ball, where Buddy and Sherman quickly transform back and forth as they literally fight for control of their single body. "We shot Buddy first, using Rick's bladder bags to make his stomach expand and his clothes balloon out. With that image on film, we could use 2-D shape deformation to extend and enhance the effect."

The same approach was employed for two shots in which Buddy's lips bulge and swell. A live-action plate of Murphy wearing a bulging lip appliance- sculpted by Ed Yang- was turned over to Rhythm & Hues, which executed some 3-D computer animation. "We created a jaw and lip that was based on Rick Baker's piece," said Rhythm & Hues visual effects supervisor Bruno George, "then animated it. The animation was fairly straightforward, but tracking it to Eddie's

face was very difficult. It also took a lot of work to get the CG lip and jaw colors to match his skin tones.”

For shots requiring a more complete transition from Buddy to Sherman, Murphy was put into Sherman makeup and photographed to create the ‘B’ side of the morph– the Buddy performance serving as the ‘A’ side. “We shot our Sherman plates, making sure that the lighting matched and that he was in the right position,” stated Farhat. “I worked on the Henry to precomp the two sides and see if the performances lined up. Then we gave those precomped tapes, along with animation sheets that we worked up, to Rhythm & Hues so that they could do the transitions.”

The most effects-intensive segment of the movie is a dream sequence in which Sherman’s girth continues to expand until he is a monster of Kong-like proportions. Sherman is first revealed in an operating room, his body billowing over the sides of a gurney. A background plate with doctors and nurses was shot first. A second plate was then filmed against greenscreen, with Murphy atop a green-covered table and fitted with bladders. “The bladders bulged just enough to get us started and take the wrinkles out of Sherman’s clothing,” said Farhat. “Mat Beck took it from there, exaggerat- ing the bulge with 2-D shape deformations, then compositing everything back together.”

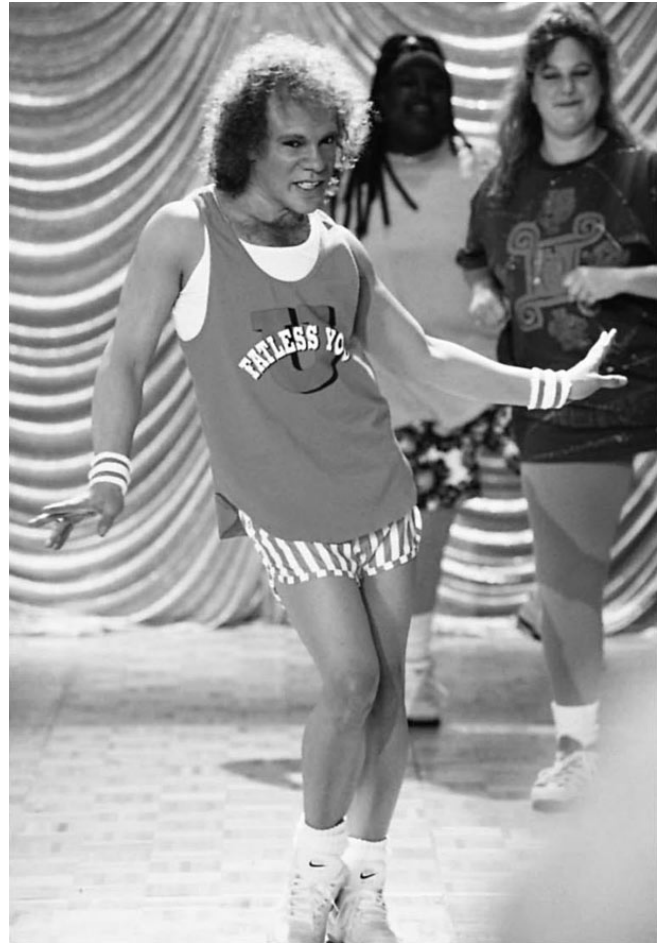
Sherman continues to grow until, pressing the attending doctor against a window and ‘swallowing’ him in fat, his massive belly bursts through the glass. Farhat and crew photographed the doctor against a pane of glass and, separately, a shatter-ing window pane, then delivered those elements to Light Matters with directions to computer generate a three-dimensional belly. Using sketches by production illustrator Dan Sweetman as a guide, Beck worked with Ernie Rinard to determine the appropriate look; then Colin Strause built and animated a 3-D belly, complete with textured sweatshirt. The shot was composited by Greg Strause.

The now-giant Sherman walks through city streets like Godzilla, his image first reflected in a glass building. A low-angled camera then tilts up to follow his progress down the street. The background plate was filmed by Farhat and crew on a Westwood street, recreated in foamcore on a greenscreen stage. "We positioned our camera on the foamcore model and had Eddie walk through it," Farhat explained. "To get the reflection, we put a piece of black plexiglass in the appropriate area." Having encoded and scaled the original hand-operated camera moves, Farhat was able to repeat them on the model. "We talked Eddie through it, making sure he hit his marks on time. He had to move at a faster-than-normal pace because we were overcranking the camera, compensating for the smaller scale with a faster film rate." The scale was also accommodated by elevating the set so that a tilt-up proportional to the one done in full-size could be executed.

In a King Kong takeoff, Sherman approaches the upper-story window of a room where a young woman lies on a bed. Sherman's gargantuan hand reaches into the room- presumably to grab the occupant - but instead plucks a roasted chicken from her room service cart. On the set, a motion control camera panned as if following the massive hand across the room. A greenscreen positioned behind the window enabled CFC to composite an element of Farhat's reaching, gloved hand into the motion control plate.

The dream concludes with Sherman's passing gas so voluminously that it causes an atomic-like explosion, complete with mushroom cloud. To define the look of the blast, Farhat commissioned Tim Clark to create an animatic. "Using Alias, Tim created this stem and cloud," said Farhat, "and it was very funny. The timing was just right, which was the key to the whole thing." Clark worked with Mat Beck to create the final shot, made up of a 3-D model mapped with paintings from nuclear bomb footage.

With their work for The Nutty Professor, Rick Baker, Jon Farhat and their crews devised the practical, photographic and digital means by which Eddie Murphy's considerable talent was allowed to shine in a variety of roles. Most fully-realized of all the characters was Sherman Klump- surely the warmest, most sincere portrayal of Murphy's career. "This movie illustrates what a brilliant actor Eddie is," Baker noted. "He was inside this man made of rubber, yet still made the character come across. I'm not belittling what we did with the makeup - it was a really good makeup- but Eddie was the one who made it come alive. He made Sherman such a lovable, real character that people on the set who would normally be intimidated by Eddie



Rick Baker also transformed Eddie Murphy into exercise guru Lance Perkins.

Murphy would come right up and speak to him. Everybody loved Sherman. On the last day of shooting that character, I felt as if I was going to cry. Everyone was sad because our good friend Sherman wasn't going to be around anymore."

ESCAPE FROM L.A. HASTA LA BUENA VISTA

article by Mark Cotta Vaz

It was a bone-chilling winter's night deep in the Texas desert and Harrison Ellenshaw was searching the horizon for a light, or any sign of the water park where his Buena Vista Visual Effects crew was filming a pair of surfers riding a stationary wave. "I was driving forever on these pitch-black back roads, thinking I was lost," Ellenshaw recalled. "I finally happened across our giant greenscreen, backing up an area where they were pumping millions of gallons of water over a still wave shape. It was very eerie and bizarre."

A few months and a great many visual effects later, those surfers would be riding a point break wave through the canyon corridor of what was once Wilshire Boulevard, one of many fantastic visions produced by BVVE for *Escape from L.A.*, a summer Paramount release and director John Carpenter's long-awaited sequel to his 1981 sci-fi cult favorite *Escape from New York*. Actor Kurt Russell— who produced the film with Debra Hill and co-wrote the script with Carpenter and Hill— would reprise his role as the surly outlaw Snake Plissken.

The year is 2013, and an earthquake of biblical proportions has transformed the San Fernando Valley into a sea and the city of Los Angeles into an island. Snake, sent on a mission to L.A. Island to retrieve a stolen secret weapon, has been given a little incentive to complete his mission within one night's time: if successful, he earns a presidential pardon and the antidote for a deadly virus with which he's been injected.

For *Escape from L.A.*, BVVE produced 180 shots depicting the 9.6 shaker and its aftermath. The devastating earthquake would be illustrated with the collapse of a trio of L.A. landmarks: Union Station, the four-level freeway interchange and the Bonaventure Hotel. For the first two, BVVE subcontracted with John Stirber's Stirber Visual Network to produce two quarter-scale models that would be shot outdoors against sky. While the Union Station destruction required a composite of the miniature and a live foreground plate of a panicking crowd, the freeway model, complete with radio controlled cars, was virtually an all-Stirber shot. Pylons on movers realistically simulated a wobbling roll, while explosive charges in the freeway columns set off the final collapse.

In a vivid example of the decreasing costs of computer generated effects, the collapse of the glittering Bonaventure Hotel— the kind of effect generally accomplished with physical models and pyrotechnics— was relegated to the CG realm due to budget restrictions. "Building the Bonaventure in quarter scale would have resulted in a 35- to 40-foot-tall model," remarked BVVE visual effects supervisor Michael Lessa. "And it would have cost at least a million dollars, which was prohibitive for our budget."

The first shot in the Bonaventure destruction sequence was designed to begin with the structure shaking, windows popping, and the hotel's five cylindrical glass towers beginning to crack and topple. The second cut would reveal the structure imploding and crashing down. The shot was also designed to literally reflect the temblor's full fury as the Bonaventure's glass

towers mirrored the collapse of some twenty surrounding buildings, also rendered in CG. To realize the virtual destruction, reference footage of the hotel was scanned by BVVE's digital artists. "The angle John picked for both shots aimed up steeply so we would have bits of glass falling into camera, really involving the viewer," said CG supervisor David Jones. "Although it was an all-CG approach, we attempted to duplicate the plate and angle John had selected. He really liked the impact of this particular approach, especially since it suggested a large-scale miniature. The idea was to hide the technique and simply let people enjoy the shot."

After some false starts on the CG front, a photorealistic, collapsing Bonaventure was realized by taking Vertigo's 3-D Vertigo software—a basic modeling and animation package that had been part of the BVVE arsenal for several years—and working with the Vancouver-based firm to design a suite of custom software that complemented the existing program. "It's fairly easy for a computer to produce a shiny, reflective surface," said Jones, "but the challenge was getting the animation just right, capturing the realism of collapsing buildings falling at the right speed and knocking into each other realistically. The technology had been close, but not quite there. By writing additional 3-D programs, we could extend the technology and achieve the shots."

An even more ambitious all-digital effort was required for a ten-shot underwater sequence in which Snake, under cover of night, pilots a mini-submarine through the newly formed San Fernando Sea. Carpenter wanted a silver screen simulation of a classic theme park ride film, with live-action cutaway shots of Snake's reactions to numerous computer generated hazards. In addition to an obstacle course of toppled buildings and wrecked vehicles, the watery world would reveal such sunken landmarks as the Universal Studios sign, the 'Jaws' ride and the Van Nuys city hall. "The initial thought on the sequence was to use digital matte painted backgrounds based on photographs of the actual route, with the CG animated sub in the foreground," Jones explained. "But matte paintings limit perspective changes, and John Carpenter was going for a really dynamic feel in the sequence. By creating an entirely 3-D environment, we could have fun with the virtual camera, chasing the sub and doing big swish-pans."

In addition to producing a realistic underwater environment, the BVVE team created bluish moonlight rippling through the water surface and the sub's searchlight beams to illuminate the



In its swan song as Disney's in-house visual effects facility, Buena Vista Visual Effects created a cataclysmic earthquake and its aftereffects for *Escape from L.A.*



A passage through the quake-formed San Fernando Sea was wholly computer generated.

iconic sights along the murky way. Accounting for lighting sources, and making them believable, would be a challenge for both effects and first unit crews throughout the film. Not only did the story call for a nocturnal setting, a central premise was that the apocalyptic quake and continuing aftershocks had completely knocked out electrical power, forcing The Island survivors to illuminate the darkness with flaring torches and trash cans set afire.

Digital matte paintings originally produced for the underwater sequence were utilized as guidelines for building the sunken structures in 3-D, with such added embellishments as texture-mapped street signs and generic CG car models supplied by Viewpoint DataLabs. "There were 500 to 600 elements for the entire sequence," said Jones. "We created the structures with RenderMan. The sub itself had numerous elements, including surface reflections of the surrounding environment, cones of light illuminating algae and plankton, and a jet of blue flame that produced a turbulent wake." To produce underwater distortion off the submarine's wake, the effects artists wrote a shader in RenderMan that generated a huge cone. "We used this cone of distortion as a key in the compositing software, basically to subtly wobble the background images and the sub lights to make it appear that the water was being disturbed. We played with the sequence for months to get the right balance of details that were noticeable, but not overwhelming. We wanted the focus to be on the sub, with the audience perceiving detailed objects on the edge of visibility as it flew through this underwater world."

Once on dry land, Snake finds no end of death-defying adventures, including the chance to ride that wave down Wilshire alongside a crazed surfer named Pipeline (Peter Fonda). That sequence was, in fact, the reason BVVE had been awarded the Escape assignment. "Some people said the sequence was impossible," recalled BVVE producer Denise Davis, "or that it would cost too much money; but we knew what our capabilities were. One of the things we needed to create the shot was a stationary point break wave so that we could shoot greenscreen surfers. Through the Internet we found the 'Flow Rider' at the Schlitterbahn water park in New Braunfels, Texas. It was a stationary breaking wave- forty-by-eighty feet wide and eight to ten feet high- that people could surf from side to side. I worked with Tom Lochtefeld- president of Waveloch and the inventor of the wave- to organize the plate photography so that Michael Lessa could shoot the elements we needed."

Two professional surfers rode the stationary wave in the chill of night during a grueling three-day greenscreen shoot. The duo were such dead-on doubles for Russell and Fonda- who were shot for closeups in a separate greenscreen session in Los Angeles- that sketchy plans to digitally paste the actor's faces onto the bodies of their surfing doubles were discarded. But the surfers were only one element of the visual puzzle BVVE had to piece together. The surfing action had to cover several miles along a nightmarish landscape in which the earthquake had pulverized the formerly four-lane Wilshire Boulevard, dropping residential and business structures and three lanes of roadway some thirty feet below ground.

Damaged structures and the Wilshire canyon itself would be computer generated, with the only live element being the waves, which were built up with separate water footage filmed at the Texas park or at the Santa Monica shore. CG artist Aaron Campbell was given the lead in producing several dozen background building ruins and detailing the rock canyon surface. Digitized reference photos shot along the Wilshire corridor allowed Campbell and Mike Ramirez

to create wire-frame versions of ruined apartment houses and storefronts, with Campbell bringing the buildings to completion using Alias software. "Some of my shots got really close to the buildings, which therefore required a lot of detail," Campbell stated. "To get the destruction look, I had to create the wire-frame model in the computer and then destroy it. Most of the virtual camera moves in my shots drifted side to side with the surfers."

"We studied a lot of surfing footage and concluded that the shots would not look right if they were locked off," Lessa added. "So for our virtual camera moves, we tried to simulate the graceful movement of surfers. None of the shots was static- even if it was a side view of the surfers wiping through. We'd still have a big swimming camera move on top to create a little more motion as the surfers slid in and out of the waves."

The surfing shots were enhanced with digital matte-painted background buildings that complemented the foreground CG structures. Lighting up the horizon was the red glow of the brush fires plaguing The Island. As with all of the powerless island shots, any flicker of illumination was welcome. "Making the canyon and buildings read at night with no lighting was tough," Lessa remarked. "There was a wash of moonlight- but the other key lights had to look as if they were coming from brush fires or burning trash cans."

Ultimately, the effects work had to match the look Gary Kibbe, the main unit director of photography, was achieving on his live-action sets and locations. "I spent a lot of time with Gary to figure out how he was lighting things so we could try and mimic his look," Lessa said. "One of the things he did was create pools of light for the characters to walk through. So for the Wilshire canyon shots, we added animated light and shadow wiping across the surfers to tie it all together."

Given the dark, moody atmosphere of the film, color timing was vital in ensuring that the effects footage matched the principal photography. "When we started a scene," noted Lessa, "Bruce Tauscher, our color timer, would usually grab the background elements and start color timing them to match the production footage. As we started making elements, we'd send them over to him, he'd do his thing, then we'd get them back and keep working on the shot. He'd get one final check to make sure everything matched. I managed to talk to Debra Hill right after they'd seen their second answer print, and she said everything had cut in perfectly, which was really good to hear."

On July 15, 1996, Buena Vista Visual Effects delivered its final Escape shots. It was a poignant end to a long-running effects tradition at Disney. After six years as the studio's in-house visual effects company, BVVE was to be dissolved, replaced by the recently acquired Dream Quest Images, which reportedly would be operated as an independent, off-site effects division.

In-house effects at Disney had first flourished during the post-World War II years, when Walt Disney turned his attention to making live-action films. Among the accomplishments of the early effects department was the development of traveling matte systems, the multiplane camera, a motion control system, and breakthrough fusions of live-action and cel animation. Along the way, the company had released such effects-powered productions as *20,000 Leagues Under the Sea*, *Darby O'Gill and the Little People*, *Mary Poppins*, *Tron* and *Who Framed Roger Rabbit*. Disney effects artists had also been lent out to work on other films, ranging from Josh Meador's

cel animation effects on *Forbidden Planet* to Ub Iwerks' supervision of traveling mattes for Alfred Hitchcock's *The Birds*.

Harrison Ellenshaw who had followed his father- famed matte artist Peter Ellenshaw- to the Disney matte department, had also lent his painting talents to a little production called *Star Wars*. With an ensuing stint at ILM and his Disney experience behind him, Ellenshaw was hired to head up Buena Vista Visual Effects, the final incarnation of the in-house Disney effects tradition. BVVE's work began with *Dick Tracy* and ended with *Escape from L.A.*, with forty features in between. For BVVE staffers- some of whom have made the move to Dream Quest- *Escape from L.A.* provided the satisfaction of going out with a bang, rather than a whimper. "Effects have changed tremendously in six years, but we've managed to ride the wave, making the right capital commitments at the right time," concluded Ellenshaw, who would be moving on. "I'm very proud of these six years; and *Escape* was a nice way to go out. In fact, this whole transition has allowed everyone to go out as winners. I have very few regrets."

THE ARRIVAL

TEMPERATURES RISING

article by Kevin H. Martin

Terraforming- the altering of a planetary environment to make it hospitable for humans- has played a part in genre films as diverse as 2010, Star Trek II and Total Recall. With The Arrival, writer-director David Twohy presents a perverse new spin on this sci-fi chestnut- the gradual transformation of earth into an intemperate tropic zone suitable for invading aliens, but not for humans.

To realize a range of illusions for Twohy's story of quiet conquest, producer Thomas G. Smith and visual effects producer Charles L. Finance utilized a band of effects facilities. Pacific Data Images created computer generated aliens; David Allen Productions executed rod-puppet animation for scenes of the aliens in modified human form; and 4-Ward Productions, David B. Sharp Productions and Hunter/Gratzner Industries all contributed miniature work. Additional effects for the relatively low-budget effort were provided by Available Light, Dream Quest Images and Perpetual Motion Pictures, while Digital Magic, Todd AO Digital Images, Computer Film Company and Title House shared the compositing workload. Todd Masters, who created prosthetic makeups and full-scale puppets, and matte artists Bob Scifo and Michael Lloyd completed the roster of effects talent.

The film opens in a verdant meadow- located, incongruously, in Greenland- where scientific researcher Ilana Green (Lindsay Crouse) is tracking alarming indications of runaway global warming. The brief sequence climaxes with a stunning pullback- courtesy of Dream Quest Images- that starts at ground level and ends with a low-orbit view of earth. The live-action portion of the shot was photographed from a crane and supervised by Dream Quest visual effects supervisor Jeff Burks and technical director Rob Burton. Recorded by a video tap mounted to the camera, the crane's move was digitized and transferred to the digital realm to provide pan and tilt information that could be applied to the subsequent computer generated segment of the pullback. A diminishing perspective of the meadow and surrounding imagery was generated by bump-mapping the appropriate textures onto a 3-D earth model created by animators Michael J. Travers and David Lauer. Government data collected from Greenland was employed to build the locale's contours into the model.

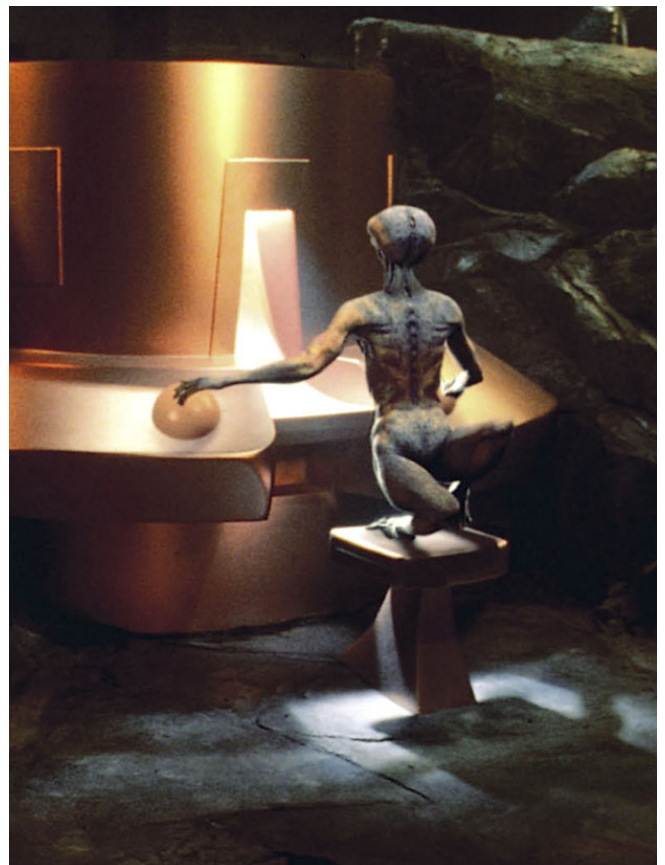
"At this point," Burks said, "the 3-D animation had been tracked to the live-action- which got it most of the way there. Then we reversed the process, tracking the live-action to the 3-D move. But there was still distortion, so David Lauer employed Elastic Reality to morph the live-action and make it conform to the animation." The same program was used to incorporate movement into the digitally painted meadow. In all, nearly two dozen layers were generated and composited into the pullback. "There have been a lot of 'cosmic pullbacks' in films, but this one was different. Instead of flying straight up or back, we pulled away obliquely, allowing the earth to roll beneath the camera to create a more vertiginous, visceral effect."

Back in the United States, radio astronomer Zane Ziminski (Charlie Sheen) is electrified by a definite- though officially unconfirmed- radio signal from 'Out There.' After reporting his findings to unreceptive project manager Phil Gordian (Ron Silver), Ziminski joins the ranks of the unemployed. Undaunted, he networks a series of home satellite dishes into a functional phased array. Eventually, his obsessive pursuit of the extraterrestrial signal leads him to a heavily guarded energy production facility- called Planecorp- located in Mexico.

Although an actual Mexican facility was used to film brief day and night exteriors, the physical location of the distinctive high-rise did not allow for wide establishing views. To realize such establishing shots, Ian Hunter and Matthew Gratzner of Hunter/Gratzner Industries were engaged to build a miniature version of the complex. "The location building was so extraordinary looking," Gratzner said, "that even in photos it looked like an architectural model rather than the real thing- so it was not easy to duplicate it in miniature and have it look realistic."



Pacific Data Images created computer generated aliens intent upon making earth uninhabitable for humans, in The Arrival.



Pacific Data Images created computer generated aliens intent upon making earth uninhabitable for humans, in *The Arrival*.

A key element of the fourteen-foot-long miniature was a telescoping antenna dish revealed rising into the sky as Ziminski approaches the complex. The antenna was designed by Hunter and Gratzner and rigged with a chain drive mechanism by Robert Spurlock. A separate, internally-mounted stepper motor opened the petals of the dish, while grain- of-wheat light blubs beneath the articulated panels created reflected highlights. Both live-action and bluescreen elements of Sheen were composited with photography of the miniature for scenes of Ziminski infiltrating the compound.

Inside, Ziminski discovers a subterranean realm of alien entrenchment, created through a variety of multilevel models. Two miniature sets were fabricated and filmed by David B. Sharp Productions to represent terraforming factories within the complex, where vapor balls of climate-disrupting gas are emitted into the atmosphere. "One miniature set was sixteenth scale," revealed Sharp, "and was shot in heavy smoke. It was used for the Ziminski character's point of view as he descends in an open elevator and passes through this enormous alien environment. Alan McFarland did all the practical lighting for the model, using a computerized setup that interfaced with the motion control cameras." The second factory miniature- revealed in a later sequence in which ingots are launched out of luge-like shoots into a huge central cauldron- was built in eighth scale, translating to a fourteen-foot-tall set. Like the first model, the luge miniature was shot in dense smoke.

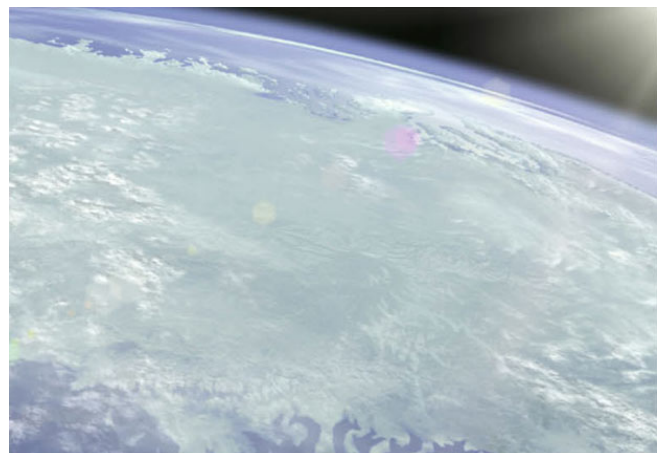
The vapor balls revealed in the factory scenes were computer generated by Perpetual Motion Pictures effects supervisor Richard Malzahn, who served as Sharp's director of photography for the



A bevy of digital techniques was employed by Dream Quest Images to produce an uninterrupted pullback from earth's surface to earth orbit.



A bevy of digital techniques was employed by Dream Quest Images to produce an uninterrupted pullback from earth's surface to earth orbit.



terraform factory model shoots. He also provided an antique process projector- converted to computerized motion control interface- for miniature rear-projection of monitor screen hieroglyphics. Finally, Malzahn contributed a digital quick-fix to shots of the irising cauldron featured in the luge set scene. "The whole unit shuts down when Charlie Sheen's character is detected," related Malzahn, "so you see the doors close up. David had created something much more elaborate than a typical iris mechanism, because that was what Twohy had wanted. But the mechanism was being severely taxed during all these long camera passes. Ultimately, I replaced it with a simpler CG model that was different in design, but was able to go right over the iris on Dave's miniature."

A bevy of digital techniques was employed by Dream Quest Images to produce an uninterrupted pullback from earth's surface to earth orbit.



A bevy of digital techniques was employed by Dream Quest Images to produce an uninterrupted pullback from earth's surface to earth orbit.

Both factory miniatures had been filmed and were about to be struck when Twohy asked Sharp to shoot some hand-held footage to represent Ziminski's POV as he tumbles from one level to the next. "I was worried about the light levels," Sharp said. "I called Chuck Finance to see if it would be acceptable to use higher speed film stock and push it one stop. He said it would be okay; so I grabbed a Fries, loaded it with high-speed film, then did a series of takes at 24 and 48 frames per second. Even with having to push the film, it looked fine."

Continuing his descent, Ziminski comes upon an alien conversion center where the creatures don human facades. The conversion center miniature was co-designed, constructed and photographed by 4-Ward Productions. "We had worked with the production designer, Mike Novotny, before," stated 4-Ward effects supervisor Robert Skotak. "He recalled a copper-bronze look we'd come up with for another show, and employed it for the look of the underground base. He designed full-size passageways leading to a cavern, where our quarter-scale conversion chamber was revealed. Together, we designed the conversion set, using digitally enhanced study models."

To assist the director in previsualizing the conversion area effects, 4-Ward first made a quick-and-dirty model, then shot stills of it and transferred the images to Photoshop. Once in the computer, the rough model was composited with images of the film's computer generated alien and a stand-in Charlie Sheen. The stand-in was created by digitally altering a photograph of the actor from another film, and matting his head onto the body of one of the members of the miniature crew. That image was then composited into the background digital mockup to synthesize the finished shot for Twohy's perusal. "I turned in that rough master of the conversion center for review," said Skotak. "When it was approved, we went directly to building the miniature itself." Layers of fiberglass were fashioned into a quarter-scale rock interior by Nick Seldon, Jim Towler and Zen Mansley. The finished miniature- measuring twelve feet

across, ten feet deep and four feet tall- was utilized in about twenty shots photographed by Mark Shelton and Dennis Skotak. "Charlie Sheen was filmed bluescreen and matted over our model background for several shots, but for the shot of Ziminski first stepping onto the conversion platform, the actor's feet were doubled by our own Jim Towler." Towler was put into a harness and lifted as he pantomimed stepping onto an invisible cushion of pulsing energy.

Composited into the various Planecorp interior models were computer generated aliens, designed and animated by PDI. Intent on avoiding the man-in-the-suit syndrome, Twohy had approved an alien design featuring legs that bent backward at the knee, creating a decidedly nonhuman, chicken-like gait. Other nonanthropomorphic features were an overlong thumb that retracted prior to conversion, and flaps at the rear of the head that alternately covered and exposed the alien's brain.

Provided with a maquette from the production art department, PDI began building the CG alien, modifying a near-perfect computer model of the human body that had been built by Dick Walsh. Since taking human animation to new heights with the free-falling digital Caped Crusader for Batman Forever, Walsh had developed a sophisticated character motion and muscular system and a genuine working model for bones, muscles and skin. "All of the muscles in the model are arranged to move bones," explained PDI executive producer Brad Lewis, "with the skin following. The system permits accurate skin and muscle deformation throughout the model, which enabled our animators to achieve a greater degree of subtlety in the motion of the aliens." Consisting of more than 300,000 polygons, the human figure model was dense, but not so unwieldy as to complicate rendering.

One of the earliest concerns was formulating a credible walking cycle for the strangely configured creature. As an aid in animating the alien's gait, animation director Raman Hui fashioned physical models of the alien in extreme poses. "Sometimes the animation looks fine from one angle, but when you see it from another perspective the illusion stops working," Hui observed. "The physical models helped me to determine if we were foreshortening artificially, or if a maxed-out limb stretch in the walk cycle was bringing the alien's body down the way it should."

While Dick Walsh was adapting his CG human into a model that would serve as The Arrival's alien, lighting supervisor Jean Cunningham and lighting designer Joe Palrang were busy devising a lighting scheme. Shot in very low lighting conditions to simulate the cave-like alien habitat, the terraform factory scenes in which the aliens appear required special CG lighting setups. In addition to matching the lighting that had been used in both miniature and full-size sets, Cunningham and Palrang added CG hero lighting to accentuate details on the alien form and show its coppery coloring to advantage. "A while back," Cunningham noted, "PDI had done a Christmas card with a thin sheet of chemically-colored copper that I just loved. Based on that- and my own work with metalsmithing- I knew we could give the alien a whole range of coppery colors and an iridescent sheen." Shaders and texture maps were applied to the model geometry to create the appropriate look. "Our 3-D paint artist, David Doepp, used our proprietary system to paint textures onto the body contours. We thought the areas most exposed to the elements might be more darkly colored, like a suntan, so we added bluish markings on the head flaps, across the shoulders, and on the backs of the hands." Instead of taking a flat texture and

wrapping it around the model, the customized paint program enabled the construct to be rotated and painted like a real object.

In addition to computer generating the aliens themselves, PDI created the conversion effect, first revealed in a shot of an alien being transformed into a woman. Starting on the CG alien and ending with live footage of an actress, the transformation employed layers of particle system animation to generate descending rings of energy around the figure. To guide the digital animators, light had been moved down and across the actress' features during the live shoot. "That gave us the timing for the effect," related animator Apurva Shah. "Each energy ring cycle added another level to the degree of transformation, progressing from an initial application of pseudoflesh to the final heating and sealing of this human-appearing skin over the alien's body."



Computer animation was employed by Available Light in producing the effects of an alien imploder device that consumes everything in its path.

While particle systems animation provided the broad strokes, the illusion required multiple refinements. "Our alien had to match the actress' breathing pattern," Shah noted, "and we had to convey a sense of heat as the skin was applied. To suggest that, we added mottling to the woman's forehead to make it look as if this flesh was sticking to her unevenly." More tweaking was required to track and replicate a live camera move on the actress. "We had a 3-D animated alien transforming into a filmed image of a live-action woman. If we'd been even half a pixel off, it would have shown up; so our tracking had to be perfect."

Escaping the complex and returning to the U.S., Ziminski arrives at his old tracking station with the intention of transmitting damning video that will expose the alien conspiracy. There, he is confronted by Gordian- since revealed as one of the principal conversion center aliens- and his alien minions. In the course of the following confrontation, one of the would-be assassins suddenly transitions into chicken-walk orientation- reconfiguring its human-looking legs- then springs upward in an incredible leap that carries it onto the roof of the building. David Allen Productions created the leaping alien by animating a small puppet mounted to a rod. Puppeteered by a crew of five, the fourteen-inch-tall figure was filmed high-speed against a bluescreen by Allen and effects cameraman Chris Endicott. Computer Film Company was responsible for compositing the bluescreen elements into the background plate.

The repeating backward leg effect was first revealed in an early scene in Mexico, in which a mysterious elderly man suddenly transforms, then performs a spectacular leap. "For the first shot in the sequence," explained Chuck Finance, "where you see the legs crack backwards, David Allen animated a set of full-size mechanical legs and shot that as a bluescreen element, eventually composited into the background." Mark Rappaport and his Creature Effects crew built both the alien puppet and the mechanical legs employed by Allen for the animation sequences.

What immediately follows is a second shot of the man bending his backward-configured legs, preparing to leap. A stuntman was photographed bluescreen, bending his legs in one direction; then, the legs were isolated and combined with another bluescreen element of the original actor bending his legs in the opposite direction. Working on the Flame, Digital Magic tracked the legs to the actor's torso and finessed the composite until a suitable image was achieved. The final cut- a high-angle POV of the man jumping from the ground to the rooftop- was realized by photographing a stuntman on wires against bluescreen. Title House removed the wires in postproduction.

After a sustained battle against the aliens, Ziminski succeeds in freezing them all solid with CO2, unaware that an alien imploder device- a floating metallic ball- has been detonated. As the intensity of the implosion wave builds, Gordian's shattered frozen arm- severed from his body and lying on the floor- begins to move, finally flying out of frame. The split-second cut was another of Allen's animation assignments. A portion of Allen's studio floor was painted and dressed to match the building in the live-action plate. Body parts from a full-size puppet of Ron Silver- created by Todd Masters for specific shots of the frozen character- were arranged in the corner and stop-motion animated as if being drawn into the whirling vortex.

Available Light designed and animated the actual imploder wave, first revealed in an earlier sequence in which Ziminski's home laboratory is virtually erased. "We ran a series of low-resolution CG tests so the filmmakers could see a variety of looks for the animated imploder force field," noted Available Light visual effects supervisor John Van Vliet. "We provided them a menu from which they picked elements they liked, and we honed down the look of it from there."

As finally designed, the imploding effect is a violent whirlpool of light that consumes everything in its path. For a view of the vortex from above the home lab, Available Light opted to go with a low-tech approach, as opposed to computer graphics. "The shot was a complete fabrication, from the ground up," observed Van Vliet. "Alan Wolfson, a freelance model builder, built a quarter-scale miniature of the room, complete with furniture, which we shot from above. Then we brought in animators, each one assigned to a fishline that was attached to a specific set piece. As flashbulbs went off, we pulled the pieces out. Once everything exited frame and the maelstrom was supposed to have started, we brought the furniture back into the vortex- this time as CG items. We had the production dig out as many set props as they could find and shoot stills of them blueprint-style- top, bottom, sides. Our modeler, Bill Arance, mapped the photographs of the props directly onto the surface geometries of CG models, so they had all the right textures- coffee stains and such." Real props and set pieces on the live-action set had been systematically removed to suggest the total destruction of objects as the



A rod puppet is photographed bluescreen at David Allen Productions for a scene in which an alien masquerading as a human makes a superhuman leap onto a rooftop.

sequence progressed. At Available Light, animator Cynthia Hyland morphed the existing set pieces to make them appear to warp under the pressure of the imploder wave before disappearing. Since all of the background plates for the imploder wave scenes had been shot static, it also fell to Available Light to add camera moves digitally.

The destruction of the radio tracking station included shots of Ziminski climbing up a cylindrical accessway toward a 120-foot-diameter rooftop tracking dish. Both interior and exterior images were captured with miniatures supplied by David Sharp. “Initially,” related Sharp, “miniatures were only going to be used for wide views of the facility being destroyed. But after the live-action was cut together, it was clear that more shots inside the building were needed. I suggested some miniature shots from beneath Ziminski, showing the tube he’s in being ripped apart. It created a greater sense of jeopardy as to whether or not he was going to make it to the safety of the dish above him.”



A collapsible tracking station miniature was built for the finale by David Sharp Productions.

Exterior views of the tracking dish collapsing as the building implodes were likewise achieved using miniatures. “The live-action portion of the scene was already shot,” Sharp explained, “so we knew how the dish was supposed to settle and which direction it was going to be facing—which worked against us. The spontaneity of the structure collapse was compromised to a degree by the need to ensure that our dish wound up landing the way it had in the live-action.”

Sharp and director of photography Russell Lyster erected a six-foot dish miniature in front of a twenty-by-forty-foot backing that matched the live-action location. “The dish needed to survive the imploder wave,” said Sharp, “so we made ours very strong, out of vacuformed acrylic and brazed steel tubing. We did a half-dozen takes on it and really beat the model up, but it held together.” A separate, eighth-scale model of the dish was constructed for closer views of the devastation.

Surviving the implosion, Ziminski confronts his young friend Kiki (Tony T. Johnson), who transforms to partial alien form—his knees buckling back—then lopes off in the odd chicken-like gait. Two shots in the scene—a late addition to PDI’s workload—required partial body replacement on footage of the actor. In one shot, PDI removed the actor’s legs and replaced them with 3-D computer generated versions, tracking the actor and lighting the CG replacements to match the original plate. The postproduction time crunch made the use of 3-D techniques too time consuming for the second shot, so PDI relied on 2-D animation and sleight-of-hand trickery. After flopping the actor’s legs to make them conform better to the alien configuration, Shah ‘cut out’ a pair of CG alien legs from the lair sequence, tracked them over the actor’s own limbs and animated them. “The alien run put the whole body off-balance,” Shah noted. “That was all right for the aliens, but when you saw Kiki moving that way, it looked

phony. To solve the problem, I balanced his body parts around an imaginary vertical axis running through the center of his body, achieving a more credible looking run.”

Since the film was supposed to be taking place during a record-breaking heat wave, PDI also had to alter the scenic background. “The mountains behind Kiki were actually snow-covered,” recalled Shah. “We replaced them right to the horizon line, cooled the colors toward blue and added CG heat shimmers to make it look more like a hot day.”

Although more modestly scaled than the summer’s other alien invasion feature, *The Arrival* still managed to showcase a wide variety of effects. “A lot of the credit for that has to go to Tom Smith,” John Van Vliet stated. “The Arrival was characteristic of the pictures he’s been involved with in that there was a high level of organization- right from the get-go, it was clear what we were expected to accomplish. But Tom always knew when it was time to step back and let us go. That’s a real virtue in a time when interference with the process can prove to be very expensive.”

THE FRIGHTENERS THE THRILL OF THE HAUNT

article by Mark Cotta Vaz

Some ghosts only go bump in the night. But in *The Frighteners*, a Universal summer release, one malevolent spirit takes the form of the hooded, scythe-wielding Grim Reaper to embark on a virulent killing spree. Only psychic con man Frank Bannister (Michael J. Fox) stands between the evil specter and the living.

For director Peter Jackson- who also wrote the script with longtime partner Fran Walsh- *The Frighteners* was an opportunity to not only spin a supernatural thriller but indulge a lifelong love of the magical possibilities of visual effects. "We wrote this ghost story with the ghosts being the principal characters," Jackson related. "I wanted them to be realized through visual effects- but the effects definitely had to service the story. My hope was that audiences would respond to the movie like they would to a roller-coaster ride through a haunted mansion."

The spectral players included the Reaper- the killer ghost who would go through several transformations in the film- as well as Bannister's trio of spirit sidekicks and a number of graveyard ghosts. The effects were even slated to provide a glimpse of heaven and hell. In all, 570 shots would be produced at the computer workstations of Jackson's own effects company. Other renaissance filmmakers had taken this course- most notably George Lucas, whose seminal *Star Wars* effects unit became Industrial Light & Magic, and, more recently, James Cameron, who co-launched Digital Domain - but Jackson organized his effects house in his native New Zealand, far from the stateside talent pool and technological resources.

Jackson began dabbling in computer generated effects with his 1994 feature *Heavenly Creatures*, a true tale based on a notorious mid-fifties case of matricide in New Zealand. Jackson's cinematic account of the murder pact between teenagers was an unlikely CG project; but having created the effects-laden *Dead Alive* with longtime associate Richard Taylor, he was determined to come to terms with the digital possibilities presented by such breakthrough films as *Terminator 2* and *Jurassic Park*. "I was aware that CG was the way effects were heading," Jackson noted, "and that both intrigued me and scared me. Part of the fun of doing *Dead Alive* was that Richard and I had been able to do the effects in-house. I wanted to keep making my movies in New Zealand; but I was worried that, with CG, I wouldn't be able to do my own effects, that I'd have to farm them all out to the States. With that in mind, Fran and I deliberately wrote the *Heavenly Creatures* script to include some CG sequences. We'd write something like, 'The girls run across a barren hillside, which magically morphs into a beautiful garden,' with the word 'morph' actually in the script."

Jackson earmarked several hundred thousand dollars of his \$2.5 million *Heavenly Creatures* budget for the hardware and software he would need to start up a digital effects department. Freight to New Zealand was an Oxberry Cinescan 6200, a Solitaire film recorder, a Silicon Graphics Indigo computer, along with appropriate software. To get things rolling, Jackson hired

his computer savvy friend George Port, who spent some four months setting up, then single-handedly produced about thirty CG shots for the movie.

During this start-up period, Jackson and his associates officially organized Weta Ltd., incorporating the computer graphics department and a creature effects shop headed by Richard Taylor. Following Heavenly Creatures, several more workstations and digital artists were added as the CG unit ramped up to produce 150 shots for a New Zealand feature called Jack Brown, Genius. At the onset of The Frighteners, the CG crew expanded further to twenty artists, who started producing images that were almost too successful. The early effects rushes so enthralled Universal executives that the planned Halloween '96 release date was moved up to summer, shortening the original work schedule by three to four months.



The Grim Reaper beckons ominously in The Frighteners. Filmmaker Peter Jackson formed a digital effects facility in his native New Zealand to handle the massive effects workload.

At that nexus, the studio proposed farming out shots to stateside effects facilities- which would have deflated Jackson's dream of keeping the work in-house. At last, the studio agreed to increase the film's effects budget, allowing Jackson to infuse his New Zealand base with more talent and technology. That breakout creative period was capped with the hiring of Wes Ford Takahashi- a former ILM effects animation supervisor- to supervise the visual effects. "When I hired Wes, it was a turning point," Jackson stated. "Our approach of growing slowly as an effects unit, which we'd taken with Heavenly Creatures and Jack Brown, had finally caught up with us. We were working with talented CG people, but no one was experienced in running a big CG department. We needed someone to come in and tie the whole thing together. Wes also had contacts in the States, and was able to get some people to come to New Zealand. We finally got another fifteen experienced CG artists to complement our core New Zealand group, ending up with thirty-five artists and thirty-five workstations."

One of the major effects challenges facing the revamped Weta was the killer ghost. Revealed as the spectral remains of executed mass murderer Johnny Bartlett (Jake Busey), the ghost worked in dark communion with his still living accomplice Patricia (Dee Wallace Stone). In addition to his Grim Reaper form, Johnny's ghost would have two further incarnations: a character the crew dubbed Wallpaper Man, which undulated underneath the walls and floorboards of Patricia's old house, and a dripping blob-like figure. All three characters would be conjured up as ingenious CG creations - although the Reaper was originally envisioned as a practical effect. "We set out with the intention of doing the Reaper as a rod puppet," commented Jackson, "maybe shooting it in a water tank. We even thought of shooting someone, dressed in costume, at different camera speeds. We did a lot of tests, but the Reaper wasn't coming across as



For the Judge - a ghost in an advanced state of decay - actor John Astin, in makeup by Rick Baker, was filmed wearing a blue torso stocking that was replaced with digital skeletal imagery.



For the Judge - a ghost in an advanced state of decay - actor John Astin, in makeup by Rick Baker, was filmed wearing a blue torso stocking that was replaced with digital skeletal imagery.



menacing and predatory. By the time we started shooting the movie, we still hadn't achieved any success with the Reaper puppet or our other practical approaches. I shot plates of Michael J. Fox reacting to the Grim Reaper, allowing space in frame for the character, but not yet knowing how we were going to create it."

For the Judge - a ghost in an advanced state of decay - actor John Astin, in makeup by Rick Baker, was filmed wearing a blue torso stocking that was replaced with digital skeletal imagery.

With the practical approach going nowhere, the production turned to a computer graphics solution. Taking the lead in creating the synthetic figure of death were Takahashi and CG supervisor Gray Horsfield, one of a supervisory team that included Wayne Stables, John Sheils and Matt Aitken. Softimage was used for walking and other primary animation, with Wavefront's Dynamation package providing such secondary animation effects as the specter's rippling robe. That company's Explore software was used for rendering and lighting.

With nearly one hundred Reaper shots required- many of which would have to be composited in with real actors and settings- the production shot its live-action plates motion control at 24 frames per second. "We'd take the data from the computer-operated motion control camera," explained Matt Aitken, "and use it to describe the path of the virtual camera for the computer graphics element. Other times, when Peter wanted to use a hand-held camera- which is part of his visual style- we'd just do a visual match-move to come up with the appropriate position of our CG camera."

While the computer generated effects were usually achieved with off-the-shelf software, more specialized effects required customized software. A case in point was the Wallpaper Man, who opens the film in grand style as dizzying camera moves follow his form scuttling through the ceiling, walls and carpeted floors. "The running ghost began with the animation of a 3-D human form," Aitken explained. "Then we'd use a piece of code that I wrote to wrap a surface over the 3-D figure. After that, it was a case of classic computer graphics techniques like texture-mapping a carpet pattern over the shape and applying shadows and lighting to match the scene." A shot of the Wallpaper Man rising up from the hallway carpet and dragging Patricia from behind required the compositing of an element of the actress being handled by a blue-suited performer- ultimately replaced with the final CG-carpeted figure- and a motion control plate of the hallway set.

The blob man, which required additional proprietary code, made its appearance in a graveyard scene wherein Bannister's astral form battles the Reaper. The Reaper is finally reduced to a bubbly blob of tar-like goo, a piece of which forms the face of Johnny Bartlett. To achieve the shot, a plaster cast of Jake Busey's head was digitized, with actual photography of the actor's face texture-mapped onto the base geometry. Spattered pieces ultimately drip into an underground crypt where the ghost coalesces into the blob character.

While the killer ghost was manifested in spectacular incarnations, other ghosts in the film were rendered as humans who had clearly gone beyond the mortal pale. "I wanted the human ghosts to be transparent and glowing," Jackson explained, "but still reasonably traditional. I didn't want some weird, shimmering thing that was so unique it would distract from the story."

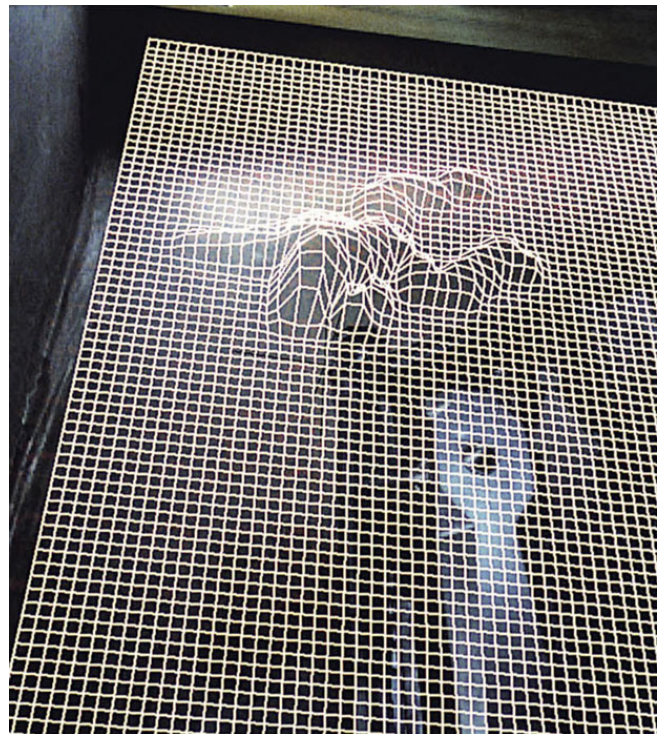
What Jackson and his team came up with was a look reminiscent of light refracting through water. “The backgrounds warp as the ghosts pass by,” said Aitken. “We combined that with a glow emanating off the characters.” The ghost actors were shot bluescreen, with the resulting elements manipulated to produce the glowing spirit effect. “Since the ghosts were shot bluescreen, they could be composited with a variable opacity. Color grading and consistency were also big issues since the ghosts were transparent and were being added onto backgrounds that changed in color as the ghosts moved past them. We had to compensate for those changes in the color of the ghosts themselves.”

Other prominent ghost characters include the trio with whom Bannister runs a haunting con. The most distinctive among them was the Judge (John Astin), a gun-slinging wraith from the Old West. While Bannister’s two other spirit partners, Stuart (Jim Fyfe) and Cyrus (Chi McBride) were somewhat recently deceased, the Judge was very old, even by ghostly standards—evidenced by his withering ectoplasmic skin and a jawbone coming off at the hinges. Because of the peculiar physical qualities Jackson envisioned for the Judge, the director called in Academy Award-winning makeup artist Rick Baker to design the character’s visage. Baker then trained Brian Penikas to apply the makeup at the shooting location in New Zealand.

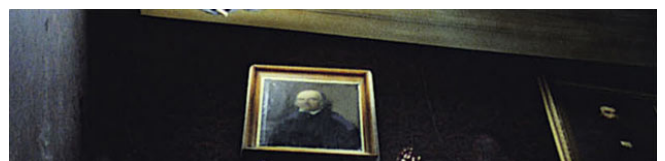
Baker started his work by inviting Astin to sit in a makeup chair still warm from an Eddie Murphy Nutty Professor makeup session conducted earlier that day. "I wanted to see how much I could do out of the kit, without putting a bunch of appliances on him," Baker recalled. "I built up some old-age stipple here and there to see how much his skin would crinkle up. Since the Judge was going to be a double-exposed ghost effect, we had to be pretty theatrical. The shadows were darker, the highlights were lighter and the overall makeup was punched up so it would read through. We probably could have done the entire makeup without appliances, but for continuity and to save time we decided it would be best not to fabricate stuff on his face every day. Ultimately, the makeup was a combination- fifty percent out-of-the-kit and fifty percent appliances, such as an acrylic lower teeth piece and a jawbone. "



For scenes of a ghost stalking its victim from within a wall, a digital human figure was animated and then draped with wall geometry derived from a motion control pass on the set.



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The finale of the film takes place on the edge of heaven, with a downward look at a gargantuan worm swallowing up the ghosts of Johnny and Patricia and diving down into the fires of hell. In the scene, the two evil spirits- floating in a tunnel of light- are about to return to their murdering haunts when the tunnel transforms into the fleshy interior of the worm. Hundreds of serpents writhe out from the wall of flesh to rip through the damned characters. Gray Horsfield headed up the sequence, producing CG snakes and using photos of fresh meat taken at a slaughterhouse as texture maps for the worm's inner body.

In a brief glimpse of heaven- where Bannister is joined by Stuart, Cyrus and Frank's deceased wife- a soft blue sky dotted with clouds and a halo of light surround the characters. "At one stage, we were trying to figure out what heaven would look like," Aitken noted. "We finally went for something indistinct and suggestive. We created cloud effects using the particle rendering capabilities of Dynamation and composited them with bluescreen elements of the actors. We used Alias for the halo because its atmospheric rendering effects are very good. For shadows, we used virtual cutout copies of Michael J. Fox and the others- a 3-D outline to match the flat, 2-D photography- with a burst of light rays coming out from behind them."

By the end of production, the fledgling effects company had succeeded in completing one of the biggest visual effects productions ever conceived and tackled outside the United States. With the baptism of fire of a big Hollywood production now behind it, Jackson and his Weta unit have begun preparing for their next film- a remake of the classic King Kong. Having established a core group of experienced computer graphics effects artisans in New Zealand, Jackson will, no doubt, use the Kong experience to expand on what he has learned and what he has built. "I'm not intimidated by CG," Jackson affirmed, "I'm intrigued by it. When I saw the CG T-rex in Jurassic Park, I felt as if I was twelve years old again. I had feelings of awe and wonder watching that movie that I hadn't had since I was a kid watching the original King Kong. As a guy who loves effects and making movies, I'm amazed and excited by what we can actually do now."

HERCULES SOLVING MYTHICAL DILEMMAS

article by Rita Street

Hercules: The Legendary Journeys- the top-rated series in syndication- features two elements essential to all great stories of myth and legend: a stalwart hero and wondrous creatures. For its hero, the series offers Kevin Sorbo as Hercules, a gentle giant who walks the show's fantasy land righting wrongs and resorting to violence only when villainy truly demands it. Its creatures are the domain of Flat Earth Productions, a company formed in 1995 by Doug Beswick, Kevin O'Neill and Kevin Kutchaver. Comprised of six individuals working from home offices on personal computers, Flat Earth is changing the face of television effects with blood, sweat and the Internet.

Hercules began life as part of Universal Television's 'action pack,' a handful of pilot shows created to entice television stations into buying more syndicated product. Studio research showed that what program buyers needed in order to command higher audience ratings were good, old-fashioned action adventures. To fill the void, Universal prevailed upon its stable of feature directors to supply five new movies. Director Sam Raimi and producer Robert Tapert were brought in to head up production on Hercules, considered the long-shot of the bunch. Fortunately, the filmmakers' offbeat humor, coupled with Sorbo's charm and some dazzling special effects, caught the fancy of viewers across the country; and Hercules became the only pilot of the lot to be picked up as a series.

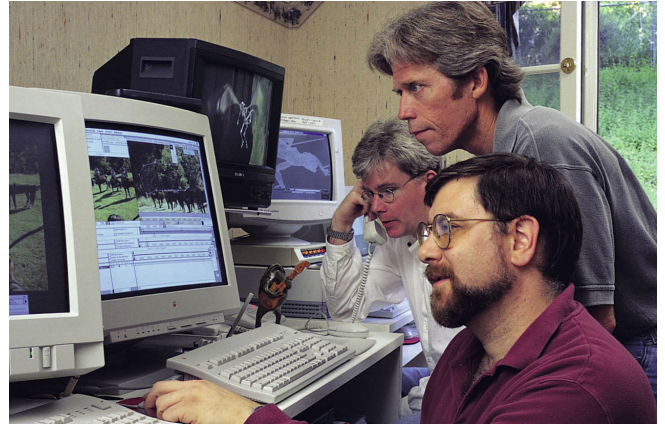
That was the good news. The bad news was that the show would be afforded a decidedly small-screen production budget. "Raimi and Tapert went to Universal with grand ideas, like creating centaurs," said effects supervisor Kevin O'Neill. "The studio responded with, 'Great- but we're still only going to give you this much time and this much money.'" The result of the budget crunch was that the crew at Flat Earth had to prove not only that their little PCs could animate, render and composite as well as more highly priced and powerful Silicon Graphics machines, but that they could generate quality work in a fraction of the time.

The first gauntlet was thrown down when the team was tasked with producing the fabled centaurs. "At the inception of the series," said O'Neill, "Tapert went around to various companies and got descriptions of how they would create the centaurs- using 3-D models and stop-motion, for example." Considering the budget restraints and the fact that Raimi and Tapert wanted the creatures to be recurring characters- appearing on screen as much as fifteen minutes per episode- the feedback obtained was less than encouraging. In fact, the issue of the centaurs became an underground joke on the Universal lot, with Tapert even receiving an anonymous cartoon of a centaur standing proudly over the producer's grave. Centaur humor aside, Flat Earth set out to create the composite creature. "In deference to the budget and the large amount of screen time, we decided to approach it from a 2-D rather than a 3-D point of view."

Early tests consisted of compositing plate photography of a horse and an actor. For the result to look believable, the actor needed to stand in one position and move his upper body during photography, imitating the pitch and yaw of the lower horse-body by watching the previously shot horse footage on a monitor. Although initial tests were decidedly rough, they proved that the approach was workable. Full-body shots were created by shipping elements of the horse and actor- shot on location in New Zealand- to Flat Earth master compositor Kevin Kutchaver.

Working with Adobe After Effects software on a Power Mac, Kutchaver generated garbage mattes to eliminate the horse's head and neck and the actor's lower body. Subsequent alignment of the horse's body with the actor's torso was aided by reference plot points applied to both the horse and the actor during the live-action shoot.

Having demonstrated their ability to build a believable centaur, the artists were immediately faced with series production demands; and it soon became apparent that the basic centaur technique would have to be modified. To provide more realistic medium shots, for example, a prop element was added- a full-scale model of a horse's back and rump that was attached to the actor.



Flat Earth principals Kevin O'Neill, Doug Beswick and Kevin Kutchaver use personal computers to produce the voluminous effects for Hercules.

Much of the work was still digital, however. Typical of the production problems faced by the Flat Earth team was a shot in which the horse was being filmed at night. "The centaur was supposed to be backlit by the moon," said Kutchaver. "It was cold that night, and steam was pouring out of the horse's nostrils like a locomotive. If that had been in the shot when it was composited, it would have looked as if steam was coming out of the actor's crotch. So Phil Carbonaro had to hand-retouch every frame in the computer to get rid of the steam. Phil just disappeared for four days to get it done." With time, the effects team became more proficient in realizing the centaurs; and eventually, more difficult shots were attempted. "Recently, we've been able to integrate actors walking in front of the centaur. We are getting more and more tricky with our rotos and crossovers; so the ultimate effect is just that much more believable."

For an episode entitled "Once a Hero," Hercules was to battle eight skeleton warriors. Before tackling the animation assignment, the effects team first choreographed the sequence. "We put eight guys in T-shirts numbered one through eight," said O'Neill, "then had them go through the choreography of the fight. We shot the battle twice- once with the actors and the guys in the T-shirts, and a second time with the actors fighting only thin air." The filmed material was then rough-cut together so that both producers and special effects artists could get a sense of the battle's flow.

Unfortunately, the T-shirt actors' swordplay was less than inspired. Although the footage provided pacing, timing and positioning, there was very little inventive 'business' for the Flat Earth animators to emulate. Gags and some real acting would have to be created for the digital skeletons. "When we all sat down and looked at the rough cut," stated 3-D supervisor Everett Burrell, "I honestly didn't know how we were going to do it. Choreography-wise it was very complicated. There



were skeletons jumping on Hercules' back, and Hercules impaling others on a candelabra and throwing them out a window. Also, these were the first creatures we had made that had not existed anywhere but inside the computer. They were not sculptures that had been scanned and they did not come from photo reference. Fortunately, once we started getting into it, it all gelled together."

The first step in the animation process was to produce a rough 'temp' that delineated the movement of skeletons through the sequence. Using this as a guide, the artists were then able to begin the laborious task of filling in movement and detail. With a scant six weeks to create forty-three digital shots- at least fifteen of which incorporated all eight skeletons- the animators had their work cut out for them. Head animator Doug Beswick addressed the challenge step by step. Even though some shots were as long as eight seconds and contained four or more skeletons, Beswick animated each figure one at a time, handing off the animation via Internet connection to Burrell, who layered the skeletons together so that several appeared in each frame. One of the problems encountered in layering the animation into background plates was that the live actors, fighting against their absent opponents, were moving too slowly. With no reference to rely on, and no real interaction, they had simply misjudged the timing. To fill in the time gaps, Burrell and fellow animator Andrew Clement added business and additional actions for the skeletons to perform.

As they advanced into their second season of Hercules, the artists attained a level of confidence that allowed them to push the capabilities of their machines and their own imaginations. In the "Fire Down Below" episode, Hercules finds himself confronted by a creature from the underworld made entirely of fire. To build an accurate template for the animators, O'Neill photographed an actor in a bright green suit. "The green suit had nothing to do with compositing," explained O'Neill. "We just wanted the actor to show up very clearly so that Doug and Everett could animate to our setups." A plate was photographed with Sorbo battling the green-suited adversary, then another with him fighting alone. The sequence was then cut together so that Beswick could determine exactly how the director envisioned the action. Meanwhile, O'Neill photographed four hours of practical fire elements against a black background. Concurrently, Burrell was busy modifying a generic male digital model obtained from Viewpoint DataLabs. Once the model was selected, Burrell set about cleaning it up and fitting it to their specific needs.

When both background plate and model were complete, the animation process began. "It was sort of like working with a rear-screen projector," observed Beswick. "I had my background, which came up digitally in black-and-white. Then I put my model in front of it and moved it around, blocking out key frames first." A renowned effects artisan with stop-motion credits on movies such as *The Empire Strikes Back* and *The Terminator*, Beswick has since made a smooth transition to computer animation. "With the computer, I'm able to view the action as soon as I create it- an advantage I didn't have with stop-motion."

While Beswick animated, Burrell and Kutchaver worked together to create a flame texture for the Fire Man that would hint at bodily structure. Combining the photographed fire elements O'Neill had supplied with fire effects created by the Pyromania software program, Kutchaver constructed a virtual Moebius strip that Burrell, in turn, mapped in collage fashion onto the

Fire Man model. In addition, Kutchaver took a filmed element that looked like a column of fire, stretched it out and doubled it over to create a flame effect that seemed to rise from the creature's feet. Lit from beneath, the character was detailed with a fractal flame effect painted around the edges with Strata's Media Paint.

Hercules' success in syndication has led to a spin-off- Xena: Warrior Princess- for which Flat Earth is also supplying the effects. The fact that the company can juggle the heavy workload for both productions is a testament to the efficiency of PC-produced effects. "These shows prove that you don't need 60,000 square feet of air-conditioned space to do quality work," remarked Kutchaver. "Because of these innovations, I think audiences are going to see a lot more independent work and many more fantastic creatures on television."

THE ADVENTURES OF PINOCCHIO PUPPETMASTERS

article by Estelle Shay

In 1881, Italian author and political journalist Carlo Collodi penned a series of installments for a children's magazine under the title Tale of a Puppet. The stories, teeming with social satire, recounted The Adventures of Pinocchio, a mischievous wooden puppet who yearns to be a real boy. Published in book form and translated into several languages, the tale—albeit a watered-down version—found its way to America where it quickly became a much-loved classic and, eventually, a Disney animated feature. Now, a more faithful retelling of Collodi's work has made its way to the big screen. In The Adventures of Pinocchio— a New Line Cinema and Savoy Pictures release, produced by Donald Kushner and Peter Locke— director Steve Barron returns to the original source material, bringing a complex character vividly to life through a skillful blending of cutting-edge animatronics and computer generated effects.

With so much of the movie riding on its title character, the essential challenge the filmmakers faced was creating a well-rounded and fully believable Pinocchio. Barron envisioned a real walking, talking character that could interact with the film's other characters. Having previously collaborated with Jim Henson's Creature Shop in London on the Teenage Mutant Ninja Turtles films, Barron once again put himself in the hands of the veteran character creators. "We talked about how to shoot the ultimate puppet," recalled Creature Shop project supervisor Jamie Courtier. "Steve Barron and Peter Locke were firmly of the belief that complex animatronics couldn't be fitted into the head of a character as small as Pinocchio. By coincidence, however, we happened to be working on a demonstration character that had a head about the same size. We put a skin on it, tested it, and that changed their minds. Then and there it was decided that we would approach Pinocchio along the lines of conventional animatronics."

Due to a tight schedule, Courtier and his team of fifty-two artisans had just fifteen weeks in which to complete their preproduction tasks. Analysis of the script revealed that nine distinct puppet types would be needed. Chief among them would be a hand-operated, waist-up puppet for closeups. Wide shots of the character moving freely or in static situations would be accomplished either with rod- or cable-operated puppets. Specialized puppets included a robot Pinocchio, designed specifically for walking, a sawdust-blowing version for a shot of the partially finished marionette, and an aquatic figure for a scene in which Pinocchio floats down a river. In addition, there were interchangeable heads capable of refined facial expression.

Using sketches provided by Barron as reference, Courtier sculpted a number of different concepts for the puppet. "It took about six weeks to find a look that meshed with everyone's ideas," recalled Courtier, who completed seven different renderings before hitting upon the right combination of characteristics. "In addition to a gentle, charming look, we also wanted a slight resemblance to Jonathan Taylor Thomas, the young actor cast as the real-boy Pinocchio—which was hard. There are nuances in a human face that just don't manifest themselves easily

in a wooden puppet.” The finished look was more subtle than cartoonish, yet not wholly realistic. “In the end, we went with good old-fashioned painted eyes. If we had created realistic eyes with lenses, the contrast with the surrounding painted wooden face would have been too great.”

With the design at last locked in, the first version of the puppet was constructed- a marionette seen early in the film as Geppetto (Martin Landau) dances his newly carved creation around the workshop. Hand-carved in wood by Christiane Koch, the marionette was built slightly undersize in comparison with the 32-inch-tall animatronic versions to follow. "Steve wanted the dynamic of shooting a larger-than-life puppet for the succeeding scenes, when Pinocchio comes to life," explained Courtier, "but we built the opening puppet a little smaller so it would be easier to maneuver."



For *The Adventures of Pinocchio*, artisans at Jim Henson's Creature Shop produced an array of animatronic puppets to represent the title character.



Pinocchio's cricket friend, Pepe, was created at Medialab via computer graphics.

As Geppetto lays his creation aside, the puppet magically begins to move of his own accord, shedding his strings. Subsequent scenes were accomplished by manipulating one of the twelve animatronic puppets fashioned by Courtier and his team. Although some were duplicates that would serve as spares or be used to accommodate second unit shooting, many of the puppets performed distinct functions. Puppet pieces were cast in fiberglass from a model sculpted in pine by Courtier. "We sculpted in wood so that we could achieve the look and feel of a real wooden marionette," explained Courtier. "That way, our fiberglass replicas would have the same characteristics as wood- chisel marks, cracks and grain texture." All of the puppet pieces were cast from the same mold to ensure uniformity, then hand-painted by Koch to impart a wood grain finish.

Three fully animatronic, interchangeable Pinocchio heads were designed to convey a full range of emotions. Lead mechanic Richard Darwin packed sixteen tiny servos into each skull, allowing for direct servo control over facial expressions such as eyebrow movement, eye blinks, left-and-right eye movement and realistic lip sync. "Pinocchio's mouth was quite human-looking," stated Courtier, "so the audience's expectations were going to be much higher than they would with a character that was totally fantasy-based."

For shots of Pinocchio from the chest or waist up, two hand-operated torso puppets- dubbed 'hot puppets'- were built. A tripod arrangement of rods connecting the neck mechanism to a handle allowed for direct control of head, body and neck movements by a puppeteer operating from below. Two additional puppeteers manipulated hands and arms via rod and trigger controls, while a fourth



Full-body scenes of Pinocchio walking with Geppetto were accomplished on location, using a robot puppet mounted on a pole arm, or on a bluescreen stage with a rod puppet.



Full-body scenes of Pinocchio walking with Geppetto were accomplished on location, using a robot puppet mounted on a pole arm, or on a bluescreen stage with a rod puppet.

operated facial expressions and lip sync. "The waist-up puppets were used more extensively than any of the others," remarked Courtier. "There was no setup time- our puppeteers could just move them into position, and off we'd go."

More complicated was the approach used for wider shots, where a full-bodied Pinocchio was required. Early on, the production had tested a rod puppet, shooting it against bluescreen so that the attending rods and puppeteers could be removed. "We had to see if we could cope with a 32-inch- tall puppet roaming around, along with five puppeteers," said Courtier, "so we built a puppet out of scraps and did a series of puppeteering and rod removal tests." Having proved the approach was viable, a fully rod-operated fiberglass Pinocchio was devised.

As an alternative to the rod puppet approach, a cable-operated puppet was also constructed. "The cable puppet allowed us to puppeteer from a distance, out of shot range," noted Courtier. "We couldn't walk it around; but it was useful in static situations where Pinocchio was sitting or standing. We could bury the umbilical trail of cables in the ground or hide them in the set." To further reduce the amount of bluescreen work, a walking rig was devised by Jamie Jackson-Moore. The rig consisted of a robot puppet equipped with a radio controlled stunt head- a less elaborate version of the hero heads. Operated on the end of a pole arm, the robot rig was supported by a small electronic dolly that ran along behind the puppet. "With just one pole connecting the puppet to the dolly, the entire contraption could be operated out of camera line, making it easier to deal with in postproduction."

Stunt puppets were also assembled quickly from a host of interchangeable parts. "We made a lot of arms, legs, hands, torsos, hips, heads and necks that we could link together to create a basic puppet for shots of Pinocchio being propelled through the air or falling off a bridge," Courtier elaborated. "Also, when facial movement was deemed unnecessary, stunt heads replaced the animatronic heads to reduce the risk of damage to the hero versions."

As preproduction drew to a close, the Henson team shifted into rehearsal mode. "We had only about three or four weeks to rehearse," remarked Courtier, "so we concentrated primarily on the rod puppetry. It was a matter of pulling together the kind of coordination the puppeteers would need to create a believable performance. Trying to coordinate all of those people and puppets to produce cohesive movement was sort of like juggling- it wasn't easy."

Eighteen Henson crew members were on hand for the live-action shoot, filmed primarily in the Czech Republic town of Cesky Krumlov. The team included ten puppeteers, with Mak Wilson orchestrating the puppet performances. "We actually planned out stages in Pinocchio's development through different puppeteering styles," observed Courtier. "We wanted a walk that would change during the course of the film from a loose-limbed gawkiness to a more sophisticated movement, culminating with him turning into a real boy." The puppeteers were divided into two groups- one for first unit shooting and the other for second. "It was a difficult task. The performances could easily have slipped into two distinct characterizations since Mak had to coordinate the puppet performances of two groups of people, both filming at the same time. He was running from set to set, trying to keep it all flowing as one."

Full-body shots of Pinocchio walking- as in his first outing with Geppetto when he humorously imitates the gaits of passing townspeople- were photographed bluescreen using the Henson rod

puppets. Measurements secured during the location shoot guided the building of bluescreen sets that matched the live backgrounds. Dressed in UV-dyed blue clothing, the puppeteers controlled the character via blue rods. In postproduction, the puppet was isolated and composited into live-action environments.

Lip-syncing to dialogue recorded by Jonathan Taylor Thomas was accomplished using the Henson Performance Control System, linked directly to the servo-controlled puppet heads. Once the prerecorded dialogue was downloaded into the system's edit suite, puppeteers could work out the lip-sync, programming in mouth movements for subsequent playback. "One track contained the dialogue, while another contained the prerecorded signals that remotely operated the servos," explained Courtier. "During the live shoot, the puppeteer could concentrate solely on the nuances of facial expression, and not worry about lip-sync, which was played back simply by pushing a foot switch."

When the words coming out of the puppet's mouth were untrue, Pinocchio's nose would grow in pronouncement of his lies. For a school scene in which it grows to alarming proportions, several fiberglass and steel noses- ranging from six inches to sixteen feet- were bolted to the puppet. "At sixteen feet," said Courtier, "we literally had to rig the nose from above, wiring it to a fishing pole contraption. Hanging by my feet from above the set, I could swing the nose, like a lateral pendulum, right across the heads of the schoolchildren, who were ducking to avoid being struck." Shots of the nose actually growing were rendered digitally.

In addition to the animatronics, Pinocchio called for nearly 350 composites and required an enormous postproduction effort. Recruited as visual effects supervisor was Angus Bickerton, who turned to a number of effects houses in England, France and Germany to accomplish the workload. Executing half of the composites was Cinemagic in Frankfurt and Berlin, while FrameStore and Cinesite in London completed the remainder.

Medialab, in Paris, was tasked with creating Pinocchio's cricket friend, Pepe, doing so entirely within the virtual realm. Working with a twelve-inch maquette sculpted by the Creature Shop's Chris Fitzgerald- based on early concept drawings by storyboard artist Brendan McCarthy- Medialab scanned and modeled a 3-D digital version of Pepe in Alias. Two skeletons were built in the computer for animation purposes: one a humanoid shape for shots of Pepe standing upright on his hind legs, and the other more insect-like, for shots in which all six of his legs were on the ground.



Henson puppeteers rehearse with a prototype of the Pinocchio rod puppet.

To animate the character, Medialab began by employing motion capture. A puppeteer donned a hard-wired bodysuit to enact Pepe's moves in real time, while another manipulated facial expressions using special gloves equipped with sensors. "Medialab brought in Eric Bergeron- who has a lot of experience in traditional cel animation- to oversee the sessions," recalled Bickerton. "The motion capture was really fascinating to watch and use; but the resulting animation just didn't look right. The bodysuit so faithfully reproduced the moves of the puppeteer that it looked too much like a man in a suit. So we ended up going back to a more conventional process, using pencil tests as key-frame guides for the animators."



Used extensively was a torso puppet requiring four operators, but little setup time.

Lip-syncing the cricket's dialogue was accomplished through a process of phoneme plotting and lip detection, programmed to a DAT tape of actor David Doyle delivering Pepe's lines. "Eric Bergeron did drawings of different mouth shapes," Bickerton explained, "which were modeled and loaded in the computer as a library of phonemes. A Medialab artist then key-framed the phonemes, morphing between shapes to smooth the transitions." Once the 3-D animation was done, the shots were translated from Softimage to Clovis- the software developed at Medialab for the animation of 3-D characters in real time. In the motion capture suite, the puppeteers used the key-frame animation and the lip-sync breakdown as reference for each shot. "All they had to animate was the rest of the face- eyes, eyebrows and nose- plus any mouth shapes that might need refining."

During rendering and final compositing in Flame, digital artists integrated the cricket into the live-action backgrounds, matching lighting and incorporating elements such as motion blur, shadows, grain and a glow effect. "The faint ghostly glow surrounding Pepe was something we used to convey the fact that Pepe is, in effect, a Ghost," noted Bickerton. "Steve also wanted it to take the edge off the realistic 3-D rendering, to soften him a bit and make him a little kinder and friendlier." Lens distortion was added to a number of shots, including one of Pepe walking on a mantle behind a glass snow shaker. "We were always trying to find interesting angles to shoot, so there are loads of strange POVs and distortions as characters pass behind objects. Flame operator Eve Ramboz added an incredible volume of 2-D animation effects on top of the 3-D images."

Other digital effects included Pinocchio's growing nose, created by Cinesite. Several shots of the sixteen-foot-long Henson nose- judged too droopy in some scenes- were ultimately replaced with a CG version. Digital artist Phil Johnson modeled the nose in Alias from photographs taken of the Henson puppet, then tracked it to points on Pinocchio's face using custom software. In compositing, Sue Rowe painted out the original nose and replaced it with the digital version. Stop-motion was also employed on a limited scale. For several shots in a rooftop scene where Pinocchio climbs up a drainpipe, Mattes and Miniatures orchestrated an eight-week stop-motion shoot on a small stage at Pinewood, with Philip Dale animating.

One elaborate scene– reminiscent of an Indiana Jones and the Temple of Doom sequence– featured Pinocchio and three school chums on a high-speed thrill ride through a mine shaft. Shots of the boys zipping through the tunnel in a small carriage were filmed live on stage, with the vehicle mounted eight feet in the air atop a motion simulator platform. A thirty-foot-tall bluescreen, with forty-foot apron attached, was positioned behind it. Floor effects supervisor Dominic Tuohy manually controlled the platform, grabbing onto handles to create a convincing rumble and shake. A cutaway chair was installed to allow puppeteer Robert Tygner to operate the waist-up puppet from below, while Mak Wilson controlled the facial animation from a Henson console.

To shoot the scene, director of photography Juan Ruiz Anchia positioned lights all around the carriage and used a mixing console to flash from one lighting setup to another, creating interactive illumination. Camera positions were also varied. “For some shots, the camera was mounted to the front of the carriage,” explained Bickerton. “We could also set it off to one side and roll the motion simulator so that it looked as if the camera was arcing over the top of the boys.”

Backgrounds for the sequence were filmed in miniature by Magic Camera Company, utilizing a series of fifth- to sixth-scale tunnels carved in polystyrene. A radio-controlled camera trolley, built by modelmaker Robbie Scott, enabled Bickerton to shoot the sequence at six to twelve frames a second. “We could have gone the way of Indiana Jones and used motion control,” Bickerton stated, “but I wanted to provide editing with a lot of takes and variations. With a really fast camera carriage going through the tunnel, we could get a lot more in.” The trolley– equipped with an Arri IIC camera, configured as compactly as possible– ran on 120 feet of eight-inch-wide track. A radio-controlled pan-and-tilt plate on the camera made it possible to follow around tight corners. Trailing behind was a second trolley, carrying batteries and power for the unit. “The nice thing was that as it went up an incline, the camera would slow naturally; and on the downhill course, there was natural acceleration. It had a real roller-coaster feel to it.”

Late in the shoot, Barron suggested an additional shot of the carriage executing a loop-the-loop before it splashes into the magic waters of Hidden Valley. “The idea was that they would come out of the tunnel into daylight, go into a full 360-degree rotation, then drop down into the fountain,” said Bickerton. When a vertical loop track, built on location, proved impractical, Cinemagic was tasked with constructing a CG version. Digital artist Thomas Kutschera built a simple box shape in Alias to represent the carriage, then mapped photographs of the real carriage onto it, along with photographs of the boys. “The carriage was going to whiz around the loop-the-loop so fast, and we were so far from it, that it really didn’t need incredible resolution.”

For a scene in which Pinocchio is swallowed by a giant sea monster, an eight-foot-long foam latex creature was designed and constructed at the Creature Shop. Pole-mounted on a crane arm, it was equipped with an animatronic face, cable-operated fins and a wire-controlled tail. A separate fiberglass section was built specifically for shots of the creature crashing into the sea. Steve Begg oversaw the three-week sea monster shoot at Bray Studios in England for Magic Camera Company, during which exterior views of the swimming creature were filmed dry-for-

wet in smoke, while others were shot in a tank with an underwater camera. "I was very concerned about the scale of the water," said Bickerton, "so I storyboarded our shots with the creature underwater. The scale underwater is much more convincing than on the surface."

Scenes inside the beast were achieved using both full-scale and miniature setups. To extend a studio set that had been built and photographed to represent the sea monster's interior, a six-foot-long model was built by Magic Camera Company and filmed on stage at Shepperton Studios. The model- supported by a scaffolding framework and fitted with fiberglass ribs and a sculpted foam interior- was hung upside-down and shot overcranked at 96 frames per second. "By turning the model upside-down," explained Bickerton, "the body ballooned out naturally, giving it more of a cavernous feel. It also allowed us to put bits of dry ice along the top of the monster to create a kind of cloud layer." For a shot of Geppetto and Pinocchio climbing up and out of the creature's throat, Martin Landau and the puppet were filmed emerging from a tubular set piece. Later, a foreground model section of the throat interior was shot and combined with the live-action footage.

Other models included a sixth-scale exterior of a puppet theater, built by Magic Camera Company and used to extend a full-size, lower-section facade employed for the live-action portion of the scene. To avoid a static composite, Bickerton did a tilt-down off the miniature, onto the live-action. "We shot a lock-off of the live-action facade, a lock-off of the miniature, and joined the two at Cinesite. Then we panned from one shot to the other to get the tilt-down. For a nighttime shot of the theater burning down, we did a number of takes and made a composite of the best bits of flames. We wanted a dramatic full moon over it all; so I shot one with my Hi-8 camera, and gave it to Cinesite where it was transferred to D-1 tape. Since it was only a small part of the shot, the resolution worked fine."

More than a year in the works, *The Adventures of Pinocchio* proved a successful endeavor, overcoming the hurdles of a tight production schedule, a foreign location and the logistics of dealing with an international slate of effects houses. For Jamie Courtier, the proof of that success was in the character of Pinocchio himself. "He carried the weight of the movie on his little animatronic shoulders," Courtier reflected, "and in doing so, he dispelled the myth that animatronics died with the advent of computer graphics. Here, the two technologies harmonized beautifully. I hope Pinocchio will stand as a charming example of how both worlds can be encompassed in our art."

NIKE COMMERCIAL EYES ON THE BALL

article by Estelle Shay

A shot of Andre Agassi slamming a tennis ball across court in a recent Nike commercial may serve to reinforce the maxim that the old ways of doing things are sometimes still the best. For the two-second scene, created by Reel EFX, a tennis ball traveling 100 miles per hour across a net and back was captured in slow motion using a method that predates the motion picture camera.

Director Tony Kaye of Tony Kaye Productions approached the Hollywood effects house to brainstorm ideas for the Olympics-related spot. "Tony doesn't like to use optical tricks if he can accomplish the same thing with real photography," stated Reel EFX vice president Jim Gill, "so shooting the ball on a rod and matting it into tennis court footage was out of the question." Kaye was intrigued with the notion of tracking a tennis ball across the net and back- on a parallel course- to create an unusual dolly shot. The approach proved unworkable, however. "We calculated the G-forces required to accelerate a camera to 100 miles an hour, then- in a few tenths of a second- reverse it; and we realized no camera could survive that."

In searching for an alternative strategy, Gill and his team found inspiration in the most unlikely of sources. "A century ago, Eadweard Muybridge set out to prove that all four legs of a horse came off the ground at once when it galloped," Gill explained. "He arranged a series of cameras with trip wires alongside a racetrack and, in essence, created the first motion pictures by firing the cameras in sequence as the horse ran by."

Recognizing that the technique might work for the tennis ball shot, Gill proposed a similar setup. "We thought, 'Why try to move a motion picture camera when we can just use still cameras to capture the image at preset intervals?' We suggested setting up an array of 35mm still cameras, all positioned in a line alongside the tennis court, and rigging them to fire at precisely the right moment. Then, in postproduction, the still frames could be arranged in proper order to make a motion picture à la Muybridge. Since 35mm still frames are about twice the size of motion picture frames, we figured we could shoot with wide-angle lenses and crop out a movie-film-size portion of each frame, moving the crop location to account for the inevitable variations in movement and shutter timing."

With the commercial shoot just two weeks away, the most pressing requirement was to locate the necessary still cameras. "We needed high-quality cameras that could be electrically triggered and were equipped with automatic film advance," related Reel EFX software programmer and electrical hardware designer Jim Lux. A connection between Andre Agassi and Canon USA- for whom the tennis star was a spokesperson- would prove fortuitous. "On very short notice, they air-freighted 150 top-of-the-line cameras and lenses to us."

Next, the Reel EFX team began viewing videotapes of Agassi at past U.S. Open tournaments to study the aerodynamics of the tennis ball, frame by frame. An air mortar was set up in the parking lot to test-launch tennis balls at a consistent serve speed so that their trajectories could

be observed and measured. "By calculating how fast the ball was moving every thirtieth of a second," said Gill, "we could determine how far apart the cameras needed to be positioned so that the ball would be directly in front of them when they fired. When we launched the ball at 100 miles per hour, we discovered that it was only doing seventy by the time it went across the net. After the bounce, it slowed down even more, to fifty or sixty."

The stationary cameras presented inherent limitations. "With a still camera, the moving ball would appear as a streak, about six inches long, against a sharp background," explained Gill. "But we wanted the backgrounds to be blurred and the ball sharp." To compensate, the cameras would have to pan to match the motion- an especially tricky maneuver, since the panning speed needed to change during the flight of the ball in relation to its changing aerodynamics.



For a Nike commercial, Reel EFX recorded the serve of tennis star Andre Agassi using an array of computer-controlled still cameras.

While testing continued, Gill and mechanical engineer Dylan Hixon set about designing the construct on which the cameras would be mounted. Built in just four days, the assembly consisted of a welded steel frame- 100 feet long by six feet high- with two racks designed to hold fifty cameras apiece for photographing the ball as it traveled in opposite directions over the net. Telescoping legs allowed for adjustments in the height of the cameras, while laser-aided alignment ensured that the camera rows would be queued up perfectly.

Based on the data obtained during testing, the cameras were configured two feet, ten inches apart at the service end of the court to allow for the faster ball speed, and one foot apart at the return end. Panning movements, ranging to 270 degrees, were achieved by mounting the cameras on urethane skateboard wheels attached to slots in the frame. A hydraulic cylinder, driven by a five horsepower pump, turned the wheels at the required speed.

An industrial pentium-based PC, running software designed by Lux, was employed to control the hydraulics and trigger the shutters on the cameras. "We had about two miles of wire connecting the computer to all of the cameras," commented Lux. "The software was responsible for determining the precise moment to trigger the cameras, corresponding with the desired frame rate of 24 to 100 frames per second. It also regulated the pan, making it possible for the cameras to go from a standing start to a smooth pan at 100 rpm in less than a tenth of a second. The panning movement had to be carefully controlled to avoid jerking, and to match the ball's speed throughout."

Once the rack assembly was completed, it was set up in the Reel EFX parking lot for two days of testing. Unfortunately, the 'dry run' was anything but dry. "We found ourselves right in the middle of a freak rainstorm," recalled Lux. "There we were, holding a plastic tarp over all our electronic equipment while we worked." Processed film from the tests was scanned into a

computer and analyzed. "I laid the film out on a big light table, and selected frames for processing. Susan Milliken spent hours scanning the selected negatives to create image files on a PC. Then, using software that I wrote to crop the desired pieces from each frame, we generated a file that could be played back on a PC and recorded to half-inch VHS videotape."

For the day-long shoot at the L.A. Tennis Club, six members of the Reel EFX team joined the production company, Agassi and nearly one thousand extras. Positioned at the baseline so that he could observe the tennis pro's serve, Gill was responsible for triggering the button that would set the cameras in motion. "We considered using an optical trigger," observed Lux, "but found that with a little practice an observer could really do it better." Before film was exposed, a number of practice runs were conducted. "The tests helped Jim anticipate Andre's timing, and fine-tune the calibration of the cameras and the panning motion. Of course, by the time we got around to doing an actual take, the sun had shifted, necessitating a reversal in the shot direction. With everyone looking on, I had to do a frantic software rewrite to run the cameras in the opposite direction."

The crew experimented with a variety of speeds and exposures as approximately twenty takes were captured on film. "We bracketed our shots around our estimations of Andre's serve speed," stated Gill. "We said, 'Okay, we estimate the initial speed of the ball at about 95 miles per hour, so we'll do passes at 90, 95 and 100 miles per hour.' Still, the shots didn't always go as planned. In one instance, we were calibrated for a 100-mile-per-hour serve, and the ball went off-speed at only 70 miles per hour. So the cameras got way ahead of the ball. In another instance, Tony wanted to shoot a Nike tennis shoe being tossed over the net, which required a radical adjustment of our frame rates and pan speed to accommodate the slower moving object. Fortunately, we had already demonstrated our ability to redo the rig on the fly."

During postproduction, the film was telecined onto D-1 videotape by Pacific Ocean Post and delivered to Mad River Post where it was digitized at low resolution. Reel EFX continued to guide the effort, advising on the final processing of the three takes selected. "Usually, we hand the film to postproduction and our work is done," remarked Gill. "In this instance, a lot of the effect happens in the framing, arranging and timing of the shot; so we needed to work with them, making sure it all fit together in the correct sequence."

Despite the low-tech nature of the approach - and the limited testing time afforded it - the end result proved remarkably effective. "We didn't have a chance to iron out all the bugs," allowed Gill, "so we just stunned them enough that they wouldn't come up and bite us at the wrong time. The important thing was that we were able to remain true to the director's vision."

FIREWORKS

article by Tim Prokop

Director Roland Emmerich and writer-producer Dean Devlin were conducting interviews for *Stargate* in October 1994 when a reporter asked if they believed aliens had ever visited earth. When Emmerich said that he did not, the journalist demanded to know how he could make his science fiction films without this belief. "Roland told him it was because he believed in the great 'What if?'" recalled Devlin. "He said, 'What if tomorrow morning you were to wake up and find fifteen-mile-wide spaceships hovering over every major city on the planet? Wouldn't that be the most startling event in the history of mankind?' Right after he finished that interview, Roland walked over to me and said, 'I have the idea for our next movie.'"

After completing the *Stargate* publicity tour, Emmerich and Devlin flew to Puerto Vallarta, where they locked themselves in a hotel room. On a laptop, Devlin wrote the screenplay, while Emmerich- a former production designer- filled large pads of paper storyboarding each scene. "We'd compare what we had done and do a lot of yelling until we finally came up with something we both liked," stated Devlin. "The great advantage was that we had the writer, the director and the producer all in the same room. By the time we had finished the script, we already had a good idea of the look of the film, the budget and how we planned to do the effects. Roland understands visual effects and knows exactly where he wants to put the camera; and that allowed us to optimize the script for the effects while we were still writing it." Script and budget completed, Emmerich and Devlin soon had a deal with Twentieth Century Fox to make the movie- their first within the Hollywood studio system, after the independent *Stargate* and, previously, *Universal Soldier*.

image



An enormous spacecraft hovers over Manhattan in *Independence Day*, a sci-fi extravaganza chronicling the worldwide invasion of earth by malevolent aliens. The film, co-written by director Roland Emmerich and producer Dean Devlin as an homage to the disaster films of the seventies, promptly broke all boxoffice records attendant to its summer opening.



Faced with a staggering number of effects and a limited budget, the filmmakers opted to produce a majority of the shots in-house, engaging visual effects supervisors Volker Engel and Doug Smith to coordinate the effort. A large digital component- guided by effects supervisor Tricia Ashford- involved several postproduction facilities and an in-house ID4 digital unit sequestered at Pacific Ocean Post. Consulting with Emmerich are digital unit compositor Conny Fauser and Ashford.

The result is *Independence Day*, a film that broke all records on its Fourth of July opening weekend and set a new standard for the term 'blockbuster.' The movie chronicles the worldwide invasion of earth by a malevolent alien species- a catastrophe seen through the eyes of more than a dozen characters, including an eccentric computer genius working for a cable television network (Jeff Goldblum), an F-18 fighter pilot (Will Smith), an alcoholic crop duster pilot (Randy Quaid) and the President of the United States (Bill Pullman). These characters form the nucleus of the counterattack that will either free humanity or doom our species to extinction.

"Structurally," explained Devlin, "*Independence Day* is an homage to the Irwin Allen disaster films of the seventies, where a lot of characters are drawn together by a cataclysmic event. Both Roland and I love those films. We had wanted to make one for a long time, but were unable to come up with anything new. At the time *Airport* came out, it worked because no one had yet captured a plane crash on video. Now, there are cameras everywhere. Riots, earthquakes, fires, tornadoes and floods are on the news every day. It's very hard to create a disaster that people haven't already seen. When Roland came up with the idea of an alien invasion, it gave us the opportunity to create a worldwide disaster."

The challenge was to make the epic story believable within a \$70 million budget. With 512 visual effects shots occupying a staggering fifty minutes on the screen, Emmerich and Devlin knew they would have to devise inventive solutions to realize their joint vision for the film. Toward that end, the filmmakers opted to produce the majority of the effects in-house, rather than employ established effects facilities. "With *Stargate*," remarked Emmerich, "we'd had the opportunity to form some of our own effects teams. *Independence Day* presented the same challenge of trying to make the film look bigger than its budget. We hired talented people we'd worked with before, added some key individuals who were recommended to us, and basically started our own effects company."

Visual effects supervisors Volker Engel and Doug Smith were engaged to oversee the effort and coordinate the activities of more than 250 effects artists. Smith, a longtime effects artisan, had contributed to dozens of films, from *Star Wars* to *True Lies*, and had headed up the effects work on a variety of theme park attractions, but had never supervised a major motion picture. The German-born Engel had supervised only the low-budget *Moon 44*- which marked his first collaboration with Emmerich- and the miniature effects for *Universal Soldier*. "After working with Volker," Emmerich said, "I sensed that he would show me something special if he were given the chance to supervise a big film. I wanted Doug Smith for the show because I had heard so much over the years about how skilled he was with complicated motion control setups. Also, Doug has a traditional effects background and has worked on a lot of classic films, which balanced nicely with Volker's experience."

In advance of the ten-month shoot, Engel was given primary responsibility for the in-camera miniature effects, while Smith was to supervise the motion control photography. Once filming began, however, there was considerable overlap in their roles. "I was pretty much tied to two motion control stages," stated Smith, "working with camera operators Jim Balsam and Harry Alpert. At the same time, there were two camera units working under Volker's supervision, with Philipp Timme and Anna Foerster serving as directors of photography. Both units got motion control equipment at various points; so there were times when we had four motion control units

shooting simultaneously. It became a little confusing, but it was the only way we could get through the volume of work that was required.”

In addition to staffing and equipping the four camera units, Devlin and visual effects producer Terry Clotiaux established a model shop headed by Michael Joyce, whose involvement in Independence Day was the direct result of the miniatures that he and his team had created for Batman Forever. Emmerich and Devlin were still in preproduction when they toured the Hughes industrial facility, where they found the model shop for Batman Forever hard at work. “Mike and his team were turning out some terrific work,” Devlin recalled. “We told him, ‘Don’t pack up- stay right here.’ Mike literally went from building the last model for Batman to building the first miniature for Independence Day.” Over the following forty-eight weeks, Joyce and a team of forty-four modelmakers produced the largest number of miniatures ever built for a Hollywood film, including airplanes, cars, helicopters, missiles, military vehicles, landmarks, landscapes, cityscapes, moonscapes and four classes of alien spaceship. “I got excited about the project when they started doing the storyboards and I could see how all the models were going to be used,” said Joyce. “I was lucky because the guys I had on this show could build anything and make it look believable. My job was to make sure that everything was finished on time and within our budget.”

A miniature and pyrotechnic crew under Joseph Viskocil was also established, along with an animatronics team supervised by Patrick Tatopoulos, a physical effects crew under Clay Pinney, and an additional bluescreen unit headed by second unit director and associate producer Peter Winther. All of the crews were set up to work out of hangars and office buildings located at the Hughes industrial complex in Playa del Rey- also the site of principal photography. “Having everything in one place was a definite bonus,” Devlin commented, “because it allowed Roland to be more involved in the visual effects. He could see everything every day and immediately make changes if there was something he didn’t like. There were also benefits just in having all this experience in one place. People could interact, see what the other people were doing and pass on ideas and suggestions that often led to better shots. By doing everything ourselves we were able to build an effects team that was totally committed to the film, and we were able to save a lot of money that was put right back into the effects. The downside was that it took a tremendous amount of work to get everything going. For most films, it is probably better to go to an existing facility and not deal with the hassle of setting it all up.”

The hassle component was intensified when, fearing that Tim Burton’s alien invasion film Mars Attacks! might beat Independence Day to the theaters, the production schedule was fast-forwarded. Despite the fact that the title tied in very nicely to the film’s scheduled July 3 release, Fox wanted the flexibility to move up the date, should that prove necessary. With a fixed start date for principal photography, the crunch was felt most by the visual effects team, which began photographing miniatures after only five weeks of preproduction, and just six weeks before the first scenes were filmed with actors.

In addition to the effects units that would be functioning concurrent with production, the filmmakers concerned themselves early on with the postproduction effects load. Digital effects supervisor Tricia Ashford- who had previously set up three facilities, including RGA/LA- was selected by Emmerich to coordinate the production of Independence Day’s computer generated

effects and digital composites, spread out among six postproduction houses and an in-house CG unit that was overseen by CG supervisors Tara Turner and Joseph Francis and by digital effects producer Steven Puri. Ashford arranged additional digital effects support from VisionArt Design & Animation, a company that would ultimately be responsible for the creation of some key effects scenes, and Matte World Digital which contributed its digital matte painting expertise.

The film's 340 digital composites were divided among five facilities, with the majority of the shots going to Pacific Ocean Post, which also provided a workplace for the in-house CG unit. "Because we were going to be dealing with shots as long as fifty seconds," stated Ashford, "we looked for a compositing house that had an advanced system for handling data. We knew that Pacific Ocean Post had this capability, but we were initially hesitant about using them because they'd never worked on a film of this scale. Once we visited their facility, we found that they had excellent people and were very interested in becoming involved."

Approximately sixty composites went to The Post Group. Nearly the same number of complex digital composites – including five shots in the climactic destruction of an alien destroyer– were awarded to Digiscope. The others went to OCS Freeze Frame. Together, these companies would digitally combine more than 45,000 photographic and computer generated elements. "We had to turn complex digital shots around in days rather than weeks, without sacrificing quality. It took a great deal of teamwork and cooperation to get the job done. I'm still amazed that we managed it."

Even as the various facilities and crews were being signed on to the show, Emmerich, Engel and Smith were initiating extensive tests to determine how best to achieve the key effects sequences. Starting with the most simple, practical solutions, the filmmakers turned to more advanced technologies only when necessary. "Because of budget limitations," Emmerich related, "we looked at where we could create practical effects, rather than resorting to expensive digital composites. We tested our ideas to see what worked and what didn't. It was a fun process of bouncing ideas around and inventing methods– all so that we could put the best effect on the screen."

One result of the testing was Emmerich's decision to rely on a low-tech approach for the cloud formations that provide a vivid backdrop to some



Visual effects directors of photography Anna Foerster and Philipp Timme inject red dye into a cloud tank during preliminary tests for a key effect– a spectacular wall of flame generated by the alien super-weapon. The effect was eventually staged using pyrotechnics on miniature sets.

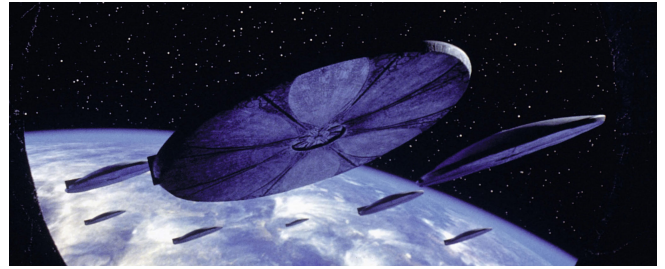


Given the largest modelmaking assignment ever for a Hollywood movie, model shop supervisor Michael Joyce– with foreman Ken Swenson–

of the aerial action in Independence Day. Scenic painter Ron Gress sculpted three-dimensional cotton fiber clouds that were photographed in separate passes with a motion control camera. "It's one of those effects that people just don't do any more," said Terry Clotiaux. "The modern attitude is to hire a Lear jet and film real clouds, which gets very expensive, very quickly. This technique allowed Roland to determine the look of the clouds. We photographed them with a motion control camera, shooting UV mattes so they could be layered in during compositing."

Also tested early on was one of the movie's most crucial effects- a spectacular wall of flame generated when the aliens fire their super-weapon. "The wall of destruction was actually inspired by Mount St. Helens," said Devlin. "We saw the smoke cloud that came out after the eruption and wondered, 'What if all that smoke was actually flame?' Suddenly, we got this image in our heads of a four-hundred-story tidal wave of fire racing down a street." Engel began exploring ways to create the effect even before arriving in the United States to commence preproduction. "The day before I left Germany," related Engel, "Philipp Timme and Anna Foerster shot a cloud tank test. They dropped red dye into a water-filled aquarium and filmed it with a Super 8 camera. Then they scanned the cloud tank footage into a computer and laid still frames over a shot of the New York skyline to help us establish the scale of the destruction wave and the way it should move through the city."

examines a lunar lander featured in the opening sequence.



A fleet of alien destroyers is launched earthward from an enormous mothership. Pacific Ocean Post incorporated the motion control models into a background plate of the planet, produced by the ID4 digital unit using software capable of projecting photo images onto a 3-D surface.



An AWACS Spy plane is sent to investigate the strange cloud phenomenon that heralds The Arrival of the alien warships. The low-tech shot consisted of a miniature plane suspended in front of a background photograph and filmed on a smoked stage. / The mysterious cloud formation advances over a rural trailer park.



The mysterious cloud formation advances over a rural trailer park.

The cloud tank approach to the wall of flame was abruptly abandoned at an early meeting between Engel, Emmerich and Joe Viskocil. "At this meeting, I told them that I could do it with models and real fire," Viskocil recalled. "It was an interesting challenge because nobody had ever tried to run fire through a miniature city and have it look this big. I couldn't just make the fire roll through a miniature towards camera- because a fireball doesn't move that way. The only direction a fireball will go is up. My idea was to position the model at a ninety degree angle- on its side- with the camera overhead. That way, I could run fire from the bottom of the model and it would rise upward toward camera; and because the model was on its side, it would look as if the fire was moving through it laterally." To test the approach, Viskocil and his team took a rough miniature rigged with gasoline and explosives and photographed it high-speed from an overhead camera. The test proved so effective that Twentieth Century Fox elected to use it in an early trailer that was broadcast to an audience of millions during the Super Bowl.

Independence Day opens with a black-and-white newspaper photograph of a U.S. flag. As the camera pulls back, the shot dissolves to a matching color composite that reveals the flag to be on the moon, near an Apollo 11 commemorative plaque declaring, "We came in peace."

The moonscape was a forty-foot-square miniature that Mike Joyce and his team created by gluing foamcore pieces over a plywood base. The relief was scaled down toward the edges, creating a forced perspective that helped blend elevated foreground sections with background pieces that represented distant mountain ranges. Once Joyce was satisfied with the relief, the model was sprayed with foam that hardened into a rock-like surface, then dressed with a combination of fuller's earth, salt, white silica sand and light gray lava rocks. Discarded paraphernalia from the various Apollo missions was built in two scales to match reference material provided by NASA.



Above Manhattan, an alien destroyer emerges from its billowing cloud cover. The atmospheric phenomenon was shot in a cloud tank equipped with underwater lighting. Digital animation by Conny Fauser enhanced the effect, while extensive digital manipulation helped to blend the footage with the destroyer, which was shot as a motion control model. Both elements were composited into background plates of New York by Pacific Ocean Post.



All eyes turn skyward as residents of a Los Angeles suburb gawk at the immense destroyer hovering over their sprawling metropolis. Digiscope composited the destroyer model over live-action plate photography.

On the Inferno, digital compositing supervisor Pablo Helman tracked and composited a computer generated starfield with the model photography. Initially, the intent had been to create background stars using Alias; but this proved impractical when the program took more than half an hour to render each frame. "We had twenty starfield shots in the show," said Joe Francis, "and some of them were hundreds of frames long. We'd have tied up our computing resources for more than a month just to render the stars. I ended up writing a stripped down, hot-rod particle system that generated motion-blurred starfields at around three seconds per frame." The initial newspaper photograph was a still-frame rendering of the composite, increased in size 150% to allow for the pullback. The still-frame was run through a newsprint filter- a grain management system that had been added to the beta version of Inferno- and a sharpening filter to give the image a texture that simulated a printed newspaper photograph.

The first suggestion that mankind is about to experience a close encounter of the worst kind comes when the flag and the NASA hardware around it begin to shake with the approach of an immense spacecraft that casts a long shadow across the lunar surface. As the vibration increases in intensity, moon dust settles into Neil Armstrong's footprints, eradicating his 'giant leap for mankind.' The sequence was created in-camera, with practical shadows and a vibration produced by a rheostatted electric motor.

The source of the shadow is revealed when the enormous alien mothership passes overhead. When the rear of the craft finally sweeps past the camera, the destination of the vessel is revealed- instantly recognizable as earth. Photographs of the planet as seen from space were utilized to create the computer generated shot. "We looked at thousands of stills," explained Joe Francis, "until finally we had a library of stunning perspectives of the earth. They were close enough to show detail, but far enough away to include the curvature of the horizon. We projection-mapped the photographs and reconstructed them in three dimensions to create a 3-D computer generated earth that could be photographed from different perspectives, with whatever camera moves the director wanted."

For the shot of the 500-mile-diameter mothership passing over camera, the model shop constructed a twelve-foot miniature, working from illustrations provided by production designers Patrick Tatopoulos and Oliver Scholl. "There are a lot of preexisting ideas about aliens visiting our planet and what their spaceships might look like," Devlin commented. "Oliver and Patrick did a great job of incorporating those ideas into their designs. We challenged them to tap into that mythology, while at the same time making the ships original, based on who these aliens are. Their technology is more organic than ours, so we wanted to create the impression that their ships are almost grown, rather than built."

The alien spacecraft that appear in Independence Day fall into four classes- the mothership, destroyers, attackers and transports. The mothership remains in orbit to coordinate the attack, while the fifteen-mile-diameter destroyers, released from docking bays on the mothership's underside, spearhead the assault on the earth's cities. When F-18s and other aircraft attempt to intervene, the attackers- small fighter-sized spaceships- are launched to provide air cover. The transports, seen only within the mothership, are rectangular spacecraft used for ferrying troops during the final stage of the invasion.

Of the four types of spacecraft, the massive mothership was the easiest to create in miniature. "The ship is supposed to be so large," explained Joyce, "that even the smallest light would have been way out of scale; so we built it without interior lighting. Another advantage, in terms of construction, was that a ship this big was never going to perform any sort of maneuver, so we did not have to build attachments for a model mover. It was photographed with a motion control camera, but the model itself was stationary."

Three different scale miniatures and separate insert sections were built to represent the saucer-like destroyers. A four-foot version was featured in a scene in which a destroyer separates from the mothership. The majority of the shots, however, were achieved with either a twelve-foot hero model or a thirty-five-foot fiberglass midscale destroyer that represented approximately a sixth of the ship and weighed almost three tons. "It was kind of a running joke that we called this our 'midscale' model," noted Doug Smith, "because it was the largest motion control model we'd ever seen. We used it to show a higher level of detail whenever the camera got close to the ship."

The domed shape of the hero model was constructed from blocks of compressed foam. Detail was carved directly into the foam, with a plywood arch added to represent the ship's bridge. "The destroyer looked simple because of its clean lines," Joyce said, "but it had a ton of detail that was all done by hand. Ken Larson, David Beasley, Dave Emery, Jim McGeachy and Greg Stuhl created hundreds of pieces that were individually sculpted, cast in urethane and glued to the top of the ship." After preliminary detailing was completed, Richard Slifka and Roberto Carlos began creating molds for the miniature spaceship. "The destroyer was so large, it was molded in two pieces. We used almost fifty gallons of RTV rubber to create two molds that weighed more than six hundred pounds each. We cast the ship in fiberglass and added a welded aluminum armature to the inside to strengthen it and provide attachment points for a model mount." The model was finalized with acid-etched metal plates, added to provide fine detail. "Photo-etching is expensive,



In addition to spacecraft and scores of buildings, the model team also constructed recognizable landmarks for ruination once the alien attack begins. Modelmaker Chris Simmons anchors a

but there was so much fine detail on this model, it worked out to be cheaper than doing all the detailing by hand. It also gave us a better look.”

Ten thousand fiber optic strands- more than twenty-eight miles’ worth- were fitted into the completed model to provide light sources for the bottom, sides and tail of the ship. “It was a monumental job,” Joyce remarked. “Whenever anyone in the shop had time to spare, he was put on fiber optic duty. We also mounted a half-dozen custom light boxes inside the model to illuminate the fiber optics.” When the internal lighting was in place, the two halves of the destroyer were joined, sealed and painted by Scott and Mark Valdes. “Scott and Mark painted the model entirely in chrome to suggest a strong metallic base, then blended nine translucent dyes over the top to give it a subtle organic look.”

Another prominently featured ship, the attacker, was also built in three scales: a twenty-four-inch version used principally for backgrounds, a forty-eight-inch one for closer photography and pyrotechnics, and a sixty-three-foot, full-size mockup built by attacker supervisor Frank Bollinger. All of the attacker models were based on sculptures by conceptual designer Tully Summers, who worked from drawings by Scholl and Tatopoulos. “We took a mold directly off Tully’s sculpture,” Joyce said, “then added fine detail before creating our final RTV rubber and fiberglass molds. We had a two-piece mold for the main body of the ship, then a separate mold for the tower that rises behind the windows. The windows were made from tinted lexan and fitted by hand. Each model was a lot of work- and we built four motion control versions and dozens of pyro versions.”

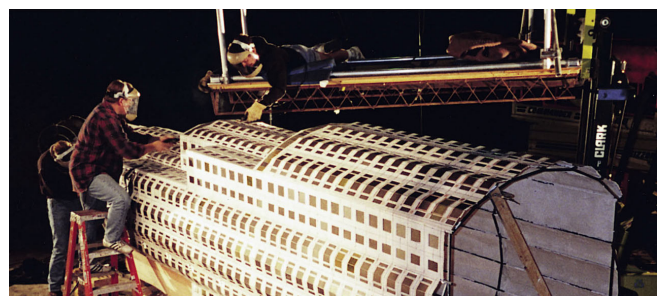
Statue of Liberty miniature to a platform in preparation for filming.



Moments before the attack, a petal-like schism, emitting particles of highly charged energy, opens in the underbelly of an alien destroyer parked directly above The Empire State Building. A mechanical schism, constructed and photographed separately, was enhanced with particle systems animation created by the ID4 digital unit, then composited by Pacific Ocean Post.



An ensuing energy blast from the alien ship reduces its targets to rubble. A pyrotechnics crew, under Joseph Viskocil, orchestrated the scenes of destruction- including a shot of the First Interstate Bank disintegrating in the attack on Los Angeles. Viskocil rigs primacord inside an eighteen-foot-tall styrene replica.

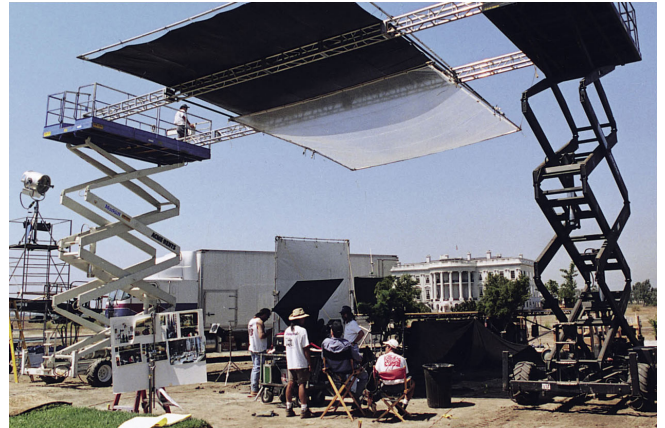


The pyrotechnics team scores the miniature in preparation for its carefully choreographed explosion.

The appearance of strange cloud formations—dubbed ‘the phenomenon’ by effects crew members—provides early warning of the impending alien attack. To create the illusion, two lighting arrays—a horseshoe shape for profiles, and a straight bank of lights for more direct camera angles—were submerged in a water tank. Thin plastic tubes placed across the front of the lights released a predetermined quantity of light gray paint into the water. When photographed with a high-speed camera, the spreading paint suggested a rapidly moving cloud bank, mysteriously lit from within.

The organic cloud elements benefited greatly from digital manipulation. “The edges of the cloud required extensive roto work,” explained Steve Puri. “We also had to clone sections and blend them over the exposed lighting rig.” One of the most difficult shots in the sequence was one in which the rim of a destroyer ship emerges from a cloud. “We had to composite the motion control destroyer over the cloud element and color-time both elements to blend them. It’s a stunning shot, and a good example of how practical and digital techniques can be combined to create a visual effect that’s stronger than the sum of its parts.”

An AWACS spy plane is sent to investigate the strange cloud phenomenon. Originally budgeted as a \$40,000 CG effect, the shot was achieved through more low-tech means after some early experimentation by Emmerich and Engel. A hundredth-scale KC-135 refueling plane from Sentai Models was modified to resemble the AWACS plane, then suspended with fishing line in front of an eight-by-ten-foot sky photograph that was placed on a dolly and lit by Philipp Timme. The camera was supported by a zero gravity arm to suggest it was filming from another aircraft, while the photograph was moved on a dolly. “Once that technique was established,”



For the alien assault on Washington D.C., the model team crafted a detailed twelfth-scale replica of the White House, complete with miniature furniture. While the destruction of the landmark was photographed at night, the model was also shot in daylight for practical scenes of a shadow creeping across the structure as the alien ship passes overhead.



Rigged with debris mortars and a mixture of primacord and other explosives, the White House model stands ready for detonation. Seven high-speed cameras were on hand to capture the blast. Footage of the exploding model was isolated and digitally composited with motion control photography of the destroyer and its open schism. A computer generated energy beam, emanating from the schism, completed the effect.

Engel said, “we used it for several other shots of planes in the air, including a dawn shot of Air Force One. To make it appear more realistic, Philipp attached a small light bulb to the top of the camera’s matte box and positioned it just out of frame. When the camera picked up the sun behind the clouds in the photograph, we dimmed the light to create an in-camera lens flare.”

“The effect was just beautiful,” added Emmerich. “There was a very natural way that the model and the photograph threw back light once the stage was smoked; and to recreate that mix digitally would have been impossible. When you’re shooting in-camera effects like this, you get movements by coincidence that sometimes create a really stunning image.”

The subsequent destruction of the AWACS plane was simulated using a twenty-foot-long plywood double of the full-size cockpit mockup in which the live-action was shot. Instrument panels, seats, doorways and electronic recording equipment were all recreated in silhouette, and the model was painted entirely in black before being suspended vertically above pyrotechnic charges rigged by Joe Viskocil. The fire that ripped through the interior of the blackened mockup was then digitally composited over the live-action photography by in-house compositor Conny Fauser utilizing the Flame system. “The silhouettes helped create a naturalistic movement as the flames moved through the cockpit,” explained Engel, “but Conny still had to do a lot of rotoscope and paint work to make it look believable. She also added exploding glass elements to the radar screens and monitors, making it appear as if they shattered just as the flames reached them.”

The clouds finally part, and the alien destroyers are revealed moving into position over major cities around the globe, their approach heralded by ominously vast shadows. The shadows were realized through a variety of techniques. “Mike Joyce and his team built a number of key landmarks in miniature for the destruction scenes that we were able to use for creating practical shadows,” commented Engel. “For shots of the shadow moving up and over the Washington Monument and the Statue of Liberty, we set the miniatures up in the parking lot so we could film them in natural light. We rigged a large canvas on the back of a truck and reversed the vehicle to block out the sunlight. For the Lincoln Memorial we used an even simpler approach- a couple of grips raised a flag in front of a light that was pointed at our model.”

The imposing shadow that blankets downtown Washington D.C. and finally envelopes the White House was created by moving a digital color correction over a background plate of the nation’s capital. The technique was also used to place shadows over a second shot of Washington D.C., a desert landscape and a view of Los Angeles. A different technique was devised for a scene in which David Levinson (Goldblum) witnesses a destroyer’s arrival from a New York rooftop. “The New York shot had a lot of height variation,” stated Tara Turner, “so a 3-D solution seemed like the best option. We created a simple wire-frame model to match the background plate and used some code that I wrote to load the motion control data for the destroyer directly into Alias. Then we positioned a digital light source to match the sun in the plate, and moved a 3-D destroyer model in front of it to create the matte for the shadow. At first, the shadow was a little too geometric; but during compositing, Ken Littleton softened the edges to make it look more realistic.”

As the immense destroyers reach their designated targets– the White House, The Empire State Building and the First Interstate Bank building in Los Angeles– traffic stops, and all eyes turn skyward. It was the unprecedented enormity of the alien spaceships that had first triggered Dean Devlin’s enthusiasm for making Independence Day. “I remember describing them to Dean,” Emmerich recalled. “I said: ‘Here is your home. You look out the right side of your house and you don’t see a spaceship, you see a ceiling that blocks out the sun. It’s so large you can’t even see the rim. Then you walk to the other side of your house, and all you can see is more of the underbelly of the ship. It’s huge and oppressive– and it’s an image that has never been seen before.’”

During production, second unit director Peter Winther shot plates in Washington D.C., New York and Los Angeles to provide backgrounds into which model photography of the destroyers would be composited. To generate the destroyer elements, the model was set up on a mount that allowed for rotational movement, then photographed by Anna Foerster. Three photography passes were digitally combined in postproduction: a beauty pass filmed in a heavily smoked stage, a lighting pass at a slower shutter speed that allowed the fiber optics to burn in, and a matte pass for separating the ship from the background. For scenes that placed the destroyer above the wave of destruction, an additional light pass was done to suggest interactive highlights emanating from the flames. A playback system– consisting of a video mixer that could overlap the on-line photography with a VHF dub of the background plate– enabled Foerster to test her camera moves and make adjustments before the destroyer was photographed.

In response to the sight of alien spaceships hovering over major cities, President Whitmore (Pullman) orders the commencement of ‘Operation Welcome Wagon’– an attempt to visually communicate with the aliens using light patterns, à la Close Encounters of the Third Kind. In the scene, a Skycrane helicopter with a large lighting array attached approaches the destroyer positioned over the White House and broadcasts a sequential pattern of light. The scene was accomplished partially as a full-size physical gag, using a rented Skycrane helicopter. “Until you see one up close,” stated Clay Pinney, “you just can’t believe how big a Skycrane is. The rotors are 72 feet in diameter. It’s a huge aircraft– which was a good thing, because the lighting rig we had to hang from it weighed 9000 pounds.” Built by Pinney from a sketch by Oliver Scholl, the rig consisted of 160 lights powered by a generator on board the helicopter. A computer controlled system allowed lighting patterns to be established, tested and saved in memory.

The lighting rig and the helicopters– the Skycrane and two flanking Hueys– were recreated by Mike Joyce and his crew for miniature effects shots supervised by Doug Smith. “There were some definite challenges to coming up with a miniature lighting rig that would appear to be in scale and that could be cut directly with the full-size rig,” commented Smith. “The rig that the model shop built included a computer controlled dimmer board that employed the same program as the live-action system, but scaled the brightness for miniature photography. Another difficult aspect of the model photography was generating a clean matte on the helicopters, which had rotors spun by a little stepper motor.” The miniature shots were composited with the backgrounds at Digiscope by Mitchell Drain, employing Quantel’s Domino.

The violent response to 'Operation Welcome Wagon' leaves no room for misinterpretation. An attack bay opens on the side of the alien craft, and bolts of energy- created in Alias by Hartmut Engel- blast the helicopters from the sky. In compositing, the energy bolts were positioned and timed to strike each helicopter a split second before it was blown apart- imagery captured through Joe Viskocil's miniature pyrotechnics.

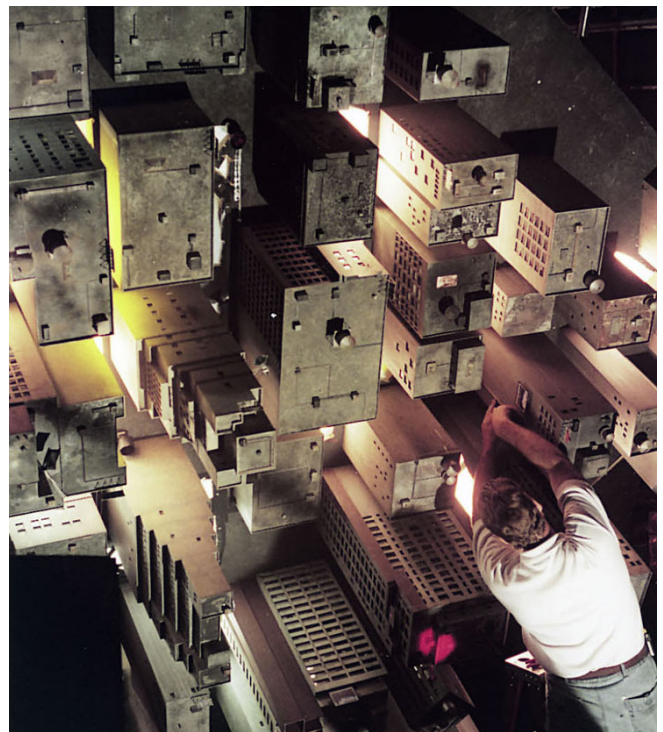
As if decimation of the 'welcome wagon' is not proof enough of the aliens' intentions, the president receives further confirmation when David Levinson deciphers the alien communication signals and determines that they are counting down to a major, worldwide assault. Within minutes, Levinson is proved right. The attack begins with the schism at the bottom of the destroyer opening like the petals of a metallic flower. Streams of brightly charged particles travel from the ends of the petals to a center cannon that emerges and locks into position. The seemingly benevolent display turns deadly as the countdown reaches zero and an intense blast of charged particles is released, triggering mass destruction below.

The schism was a nine-foot mechanical insert model, engineered and constructed by Eric Heisler, that was photographed separately and composited onto the underside of the destroyer. "Eric did a terrific job with the mechanics," remarked Engel. "They were operated through motion control, so the movement was programmed through the same source that controlled the camera. To help everything run smoothly, we filmed the model upside down with the cannon rising into the air, then rotated it 180 degrees during compositing."

The energy particles within the schism were created digitally by Stephane Couture, who also animated the energy blast that is launched once the particle accumulation is complete. "The effect progressed in three distinct stages," explained Joe



As a wave of destruction sweeps through Washington, the Capitol dome is engulfed in flames. Joe Viskocil and his pyrotechnics team prep the dome model, elevated and positioned facing up. Filmed from above, the fire ignited from below would rise and appear to travel laterally over the structure.



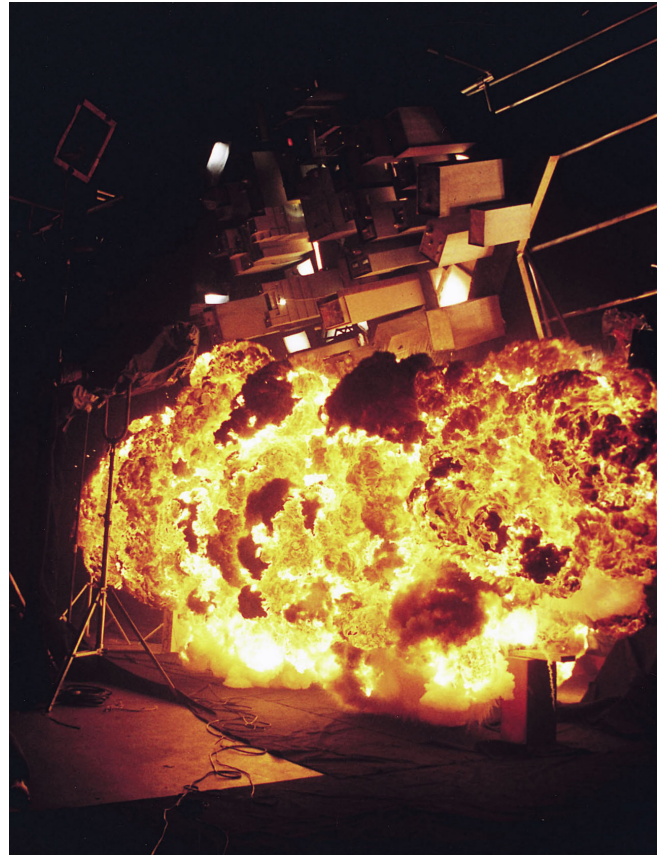
Modelmaker Alan Faucher adds last-minute detailing to a miniature New York cityscape,

Francis. "Stage 1 is an intense beam of light that acts like a laser sight, determining exactly where the destruction will occur. Stage 2 is a buildup of charged particles that collect around the energy cannon like the windup before the pitch. Stage 3, which we called 'the hammer,' is an intense blast of particles that travels down the beam and slams into its target." A particle system was employed to generate the three-phase energy effect. "Particle systems animation was the perfect technique for simulating the collection of energy within the schism. We used turbulence to control the speed of the particles, creating undulating streams of particles that collect inward." Using the Quantel Domino, Mitch Drain at Digiscope aligned the particle streams to the end of each petal. Computer generated flares of light were also composited over the buildup of particles to suggest the increasing energy in the middle of the schism.

Bearing the brunt of the energy blast in Los Angeles is the First Interstate Bank building, the top third of which was recreated as an eighteen-foot-tall, seven-foot-wide model. Another building destroyed in the global conflagration is The Empire State Building, also replicated in miniature. After the fourteen-foot-tall replica had been photographed for the 'before' portion of the destruction sequence, its internal wiring and lights were replaced with pyrotechnics. "Rigging that model to blow was a delicate operation," stated Joe Viskocil. "It had already been filmed, so if we moved it even a little, the camera passes would not line up. There was only enough space under the miniature for one person, so I laid on a dolly, like a mechanic under a car, and rigged the model while my crew prepared the explosives. These guys are the best in the business; so we were able to lay in twelve circuits of primacord and four circuits of explosives in a little under two hours."

To create a more spectacular effect, Viskocil choreographed the explosion to progress from the top of the model to the bottom in twelve distinct stages. "I wanted to walk the explosion down the building, rather than have it go off in one big bang. Big bangs work great for cars, but they aren't very dramatic in buildings as large as this one." The first area to be destroyed was the top of the tower, which was shattered with primacord. "After that, I detonated the first-stage explosives and gas just before igniting another four layers of primacord in quick succession. We continued that pattern along the length of the building, setting off explosives just before the

erected vertically for a shot of the enormous fireball tearing through the city streets.



The fire— a combination of chemicals, black powder and gasoline— is ignited in metal troughs running along the length of the miniature. With timing crucial, a computerized firing device was rigged to precisely orchestrate each stage of the explosion at a predetermined moment.

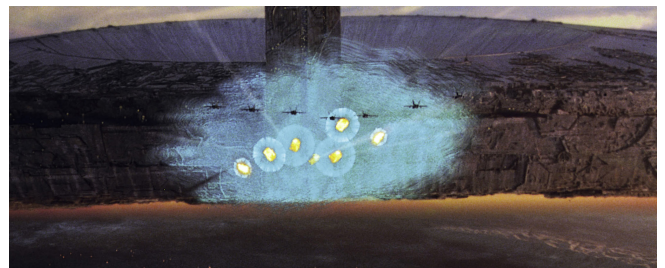
primacord.” To capture a spectator’s point of view, a high-speed camera was positioned near the base of the model to photograph the explosions as they worked their way toward ground level.

The alien assault continues with the demolition of the White House, accomplished with an elaborate miniature fashioned by a team of fourteen modelmakers over a span of three months. “We started by looking at all the reference books we could find on the White House to figure out what scale to build it in,” said Joyce. “We finally decided that one-twelfth scale was about the smallest we could go and still have it look realistic when we blew it up. That translated to a model that was fourteen feet wide and about five feet tall.”

With the scale determined, the building was sculpted in sections by Greg Stuhl and Chris Simmons. Molds fashioned from those sculptures were used to cast each piece in tinted plaster. “Even though it is the ‘White House,’” noted Joyce, “we added a little black to bring it down in value. If the plaster had been pure white it would have looked like a miniature when it shattered. We hoped to get the shot right the first time; but to be safe, we cast two pieces from each mold and a few extras in case of breakage. Then Mark and Scott Valdes painted them, and we added urethane window frames, glass windows, miniature curtains and interior lights.”

Miniature furniture was positioned inside the White House model in the hope that some of the objects might show up in the explosion. “I put in wooden chairs, televisions, computers, paintings, desks, lamps and even a toilet,” stated Engel, “because there’s a definite visual impact when you see recognizable objects in an explosion. I just hoped something would survive long enough to be seen by the camera.”

The destruction of the landmark was filmed at night, with most of the crew gathered to watch. Seven cameras, running at speeds of up to 360 frames per second, were positioned to capture the action from a variety of angles. Viskocil’s pyrotechnics tore the model to shreds instantly; but when replayed at normal speed, the shot had all the force, texture and debris the crew had hoped for- everything, in fact, except the toilet. “The explosion was just terrific,” Mike Joyce commented. “I love it when Joe blows up my models because he’s the best there is. And I really love it when we get the shot on the first take because then we don’t have to rebuild the model!” As with the other building explosions, the destruction of the White House was accomplished through a combination of primacord and other explosives. The primacord shattered the plaster facade at the precise instant that twenty-four debris mortars blasted their contents through the structure, immediately followed by a huge fireball.



In the aftermath of the attack, an F-18 squadron- launched from a Marine base in California- fires air-to-air missiles at one of the destroyers, only to see them explode harmlessly against an invisible shield surrounding the ship. VisionArt composited the shots, contributing computer animated airplanes, missile trails and the shield effect.



The downed Statue of Liberty lying in New York Harbor, seen against a backdrop of burned-out skyscrapers, presents a chilling view of the devastation. The statue - a five-foot-tall foam

With the Cineon compositing system, brothers Lawrence and Ken Littleton rotoscoped the White House explosion footage, digitally compositing the imagery in front of motion control photography of the hero destroyer and the open schism. The energy beam was then added, timed to strike the model an instant before it was blown to pieces.

Careful rotoscoping placed the beam and the energy blast that follows behind a railing at the top of the White House to make it appear as if the weapon was striking the center of the building.

While his home is being blasted into splinters, the president awaits takeoff aboard Air Force One. An exterior shot of the plane taxiing into position was created in-camera using a four-foot-long 747 model, detailed with presidential markings and pulled by wire through a ten-foot-square tabletop representation of Andrews Air Force Base. Shots of the plane accelerating and finally lifting into the air were filmed motion control by Doug Smith, and composited over an advancing flame element at Pacific Ocean Post.

To show the devastating impact of the alien super-weapon on cities across America, Joyce and his crew fashioned 1/24th-scale city street miniatures representing Los Angeles, Houston and New York. For the New York shots, the model makers also constructed a 1/96th-scale miniature. "We created three New York streets, a portion of Houston, one very large Los Angeles street and a few smaller intersection-type pieces," said Joyce. "We also built several clusters of three or four buildings, a few generic stand-alone buildings and some sixth-scale interiors, specifically for the purpose of blowing them up."

Teams of two to four modelers were assigned to each miniature city section. Working from reference photographs, the modelers constructed building shells out of plywood covered with several coats of plaster. The shells and street surfaces were painted, then detailed with fire escapes, billboards, antennas, telephone lines and parking meters. "Having a thick layer of plaster on the outside of the buildings helped make the miniatures resistant to fire," commented Joyce, "and allowed us to film multiple takes with only quick cleanup and redressing required. Plaster also creates great debris when it is blown up. When we mixed the plaster, we'd add a brown or gray tint to it so that you wouldn't see white edges in shots of the buildings shattering." Fortunately, the flames passed through the miniatures so quickly that there was usually not much damage- except to the lights and gels, which had to be replaced after each take. "We found that the streetlights had a tendency to melt; so rather than trying to salvage them, we would create as many sets as we needed in advance and plug them in when we redressed the miniature."

The fireballs that blast through the cityscapes were created with a combination of chemicals, black powder and gasoline that Viskocil and his team carefully placed in metal troughs running along the bases of the miniatures. "That was our basic setup," said Viskocil, "but for some shots with taller buildings we placed two troughs in a 'T' formation so that we would have flames rolling along the street, and also filling the top of the frame. To create an even wall of flame, we

replica- was composited against a forced-perspective miniature backdrop, filmed separately. Pacific Ocean Post assembled the shot, incorporating more than thirty additional layers, including dozens of fire and smoke elements, a background plate of the sky, the destroyer and schism, and digital enhancements such as surface reflections in the water.

ignited the whole trough at the same time, with between thirty and forty igniters spread out over its length and set off with a single button.” As the flames swelled upward they would strike the wooden base of the miniature, which was placed at an angle to ensure the flames would remain in contact with the ‘ground’ as they were channeled along the streets toward the camera.

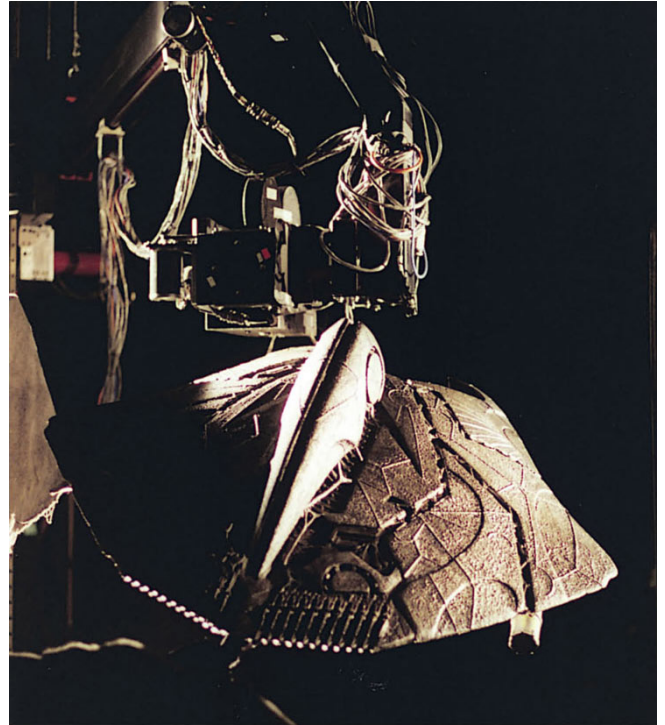
The detonation sequences generally began with the ignition of gas and propane charges. That explosion was followed by powder bombs, packed into mortars and covered with plastic debris that was projected toward the rear of the model. At the precise moment that the fireball and the debris reached the facade, the plaster was shattered with primacord. The timing for the detonation of all these different explosives was crucial- and much too critical to allow for human error. “A nail board wasn’t precise enough to accomplish this,” Viskocil noted, “so I built a motion control firing box specifically for this show. The mechanism is accurate to 1/1000th of a second, and it worked so well that we ended up using it for almost every shot.” Since the size and position of the buildings varied, the timing settings had to be determined separately for each scene. To calculate those settings, Viskocil conducted tests using the timing board to set off flashbulbs, photographed at the appropriate camera speed. When the tests were replayed at normal speed- 24 frames per second- Viskocil could see the exact moment each igniter was triggered, and make adjustments without destroying expensive models.

For many shots in the massive assault sequence, Viskocil’s pyrotechnics had to be digitally combined with live-action elements. “When the aliens strike,” explained Engel, “the streets are jammed with cars and people trying to flee the city- and all of those elements had to be created and combined with the explosions. Roland wanted the scenes of destruction to be exciting rather than horrifying, so we deliberately avoided angles where we would have had to show people being burned.” People seen fleeing the flames were actually extras filmed against a bluescreen by Peter Winther. Engel also has a cameo in the scene- a closeup of an office clerk who is blown away when the office building explodes.

To achieve scenes of tumbling cars, hundreds of kit models were assembled, then either tossed by cable on the miniature sets or blasted from air cannons and photographed bluescreen. Philipp Timme was instrumental in making the model cars look believable in the shots. "Philipp has a lot of talent with interactive light," Engel asserted. "He knew exactly where each streetlight was in the miniature, and where reflections should be recreated on the car windshields. Another neat lighting trick he used was waving hula skirts made from strips of orange gel in front of lights to suggest the illumination from flames that would be composited in later."

For a spectacular wide shot of Los Angeles that establishes the ring of fire and the alien destroyer overhead, the digital team duplicated the look of Viskocil's pyrotechnics. "We composited the destroyer in first," explained Joe Francis, "because that gave us a good reference for positioning the expanding circle of flame, which we created using particle systems animation. Model photography of the destroyed city was matted in behind the ring as it moved outward. We also modeled a number of generic buildings and placed them in front of the particle systems fire so that it would interact with geometry and not just move across a flat plane."

Some of the most exacting shots in the massive destruction sequence are featured in a scene in which hundreds of people- including Jasmine (Vivica Fox) and her dog- are trapped as a wall of flame tears through the Third Street tunnel in downtown Los Angeles. Closeups and reverse angles looking away from the flames were photographed in the actual tunnel, while other views were staged within a sixteen-foot-long, four-foot-diameter replica that was painstakingly detailed and painted to match. To create usable flame elements, Joe Viskocil blasted a fireball through the miniature.



Attacker aircraft, launched from the destroyer to engage the F-18s, were designed with an organic look and choreographed like a swarm of bats in flight. A four-foot model is photographed by a motion control camera for a flyby shot. Though miniature work was extensive, two elaborately staged dogfights relied heavily on computer animated attackers and airplanes, with the digital images proving largely indistinguishable from the models.



For a high-speed, Daredevil chase through the Grand Canyon, a scaled section of the canyon was replicated as an outdoor set, with a miniature F-18 flown on wires amidst pyrotechnic effects. Other shots employed motion control miniatures composited into aerial footage photographed in the Little Colorado Canyon.



As the flames sweep through the confined space, vehicles are tossed against the top and sides of the tunnel. Although a Harley-Davidson that crashes into the wall in front of Jasmine was shot as a motion control model by operator Jim Balsam, the remaining vehicles were shot by Engel within a transparent shell that matched the interior

dimensions of the tunnel miniature. The shell was positioned over an incline ramp, with the camera placed in the same relative position as the pyro photography, aimed toward a bluescreen at the opposite end. Air cannons thrust miniature cars into the air, where they smashed against the ceiling and rebounded back to the ground. The digital team at Pacific Ocean Post composited the tumbling cars into the miniature tunnel, complete with Viskocil's pyrotechnics and some stock debris footage to sweeten the shots.

The transparent dome posed difficulties for the compositors because of light spill from the bluescreen. "The blue reflected onto the tunnel, which also reflected onto the windshields of the cars," stated Tara Turner. "All of those reflections had to be painted out by hand. It also took a lot of finessing to make everything line up. The model photography had to be matched to full-size elements of cars and running people that had been shot second unit. In some shots, people were running between full-size cars on the stage, and we'd have to composite those elements into the miniature. Other times, we had to shrink Jasmine and the dog down and place them between miniature cars. Getting the right interactive light on everything so that it would look as if it belonged together was really tricky."

The compositing task for the tunnel sequence was complicated by the fact that the dog was not included in the original elements. It was not until two weeks after the effects had been shot, when Emmerich was filming in the Third Street tunnel, that the dog was added to the film. "We started shooting, and I could see that the scene just wasn't working," said Emmerich. "The effects were terrific, but there was no emotional impact. So we added the dog, making him the last one to be saved. We decided that the dog would leap from a car, jumping to safety just as the vehicle was overcome by flames. It became one of my favorite scenes in the movie. The first time we tested it, the audience screamed. The emotional context gave the visual effects real impact on the screen."

On hand throughout the live-action shoot within the tunnel was physical effects supervisor Clay Pinney, who contributed not only routine atmospheric effects such as wind and smoke, but also three shots of full-size vehicles flipping as if they were Matchbox toys. "Roland is very clever about how long he stays on a miniature and when he cuts away," noted Pinney. "In this scene, you see all the cars lifting and coming forward in miniature; and just before it starts to get unbelievable, he cuts to a shot of real cars flipping. That little real moment suspends disbelief and allows the audience to really appreciate what they are seeing."

To overturn the cars, Pinney modified a technique he had developed for the opening sequence of *The Specialist*, in which a pneumatic ram was used to lift the front end of a Land Rover eleven feet into the air. For Independence Day, larger cylinders provided more than 17,000

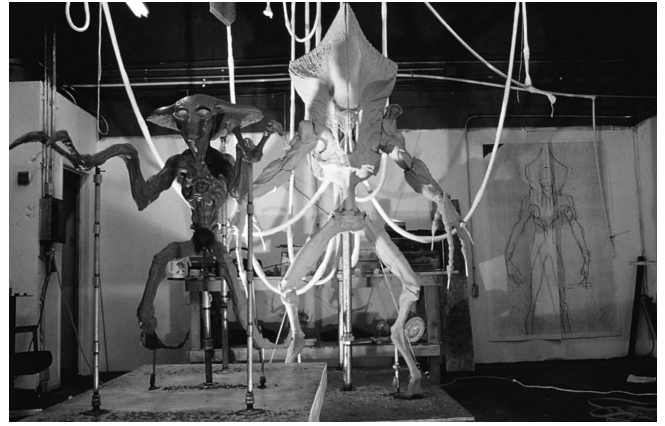
The crash-landing of the alien attacker was filmed outdoors on a forced-perspective set, tilted slightly to encompass a real sky background. Timed to pass through the fireball created by an exploding F-18, the spaceship model was propelled along metal rails set up like a ski jump, then launched into the desert landscape set via a bungee cord mechanism.

pounds of force to flip the cars completely over. When the cylinder was activated, compressed air drove the ram upward and forward like the arm of a mousetrap. "Cables were attached to hooks on the front of the car," Pinney elaborated, "so the system was self-releasing. When the vehicle pivoted on the ram and reached a certain angle, the cables would disconnect, and the car would be free to fly through the air. The advantage of this system was that it was very precise. Once we tested it, we were able to calculate exactly where the car would land." Eleven cars were flipped over the course of the production. As confidence in the rig grew, Pinney and stunt coordinator Dan Bradley attempted a shot in which a stunt performer was actually positioned inside an overturning BMW. "As soon as the flipping car was high enough that the stuntman could no longer be seen by the camera," explained Pinney, "we tripped a bungee cord that pulled him across the flattened passenger seat. The bungee held him down very tightly in that position so he wouldn't be hurt when the car made contact with the ground."

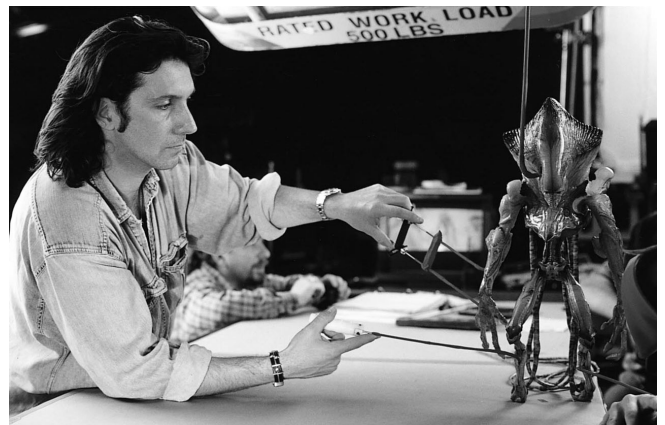
Pinney and Bradley also combined their talents to generate full-size explosion scenarios that would be intercut with miniature pyrotechnics. Three flats representing a house, a store and an office were rigged with a potent mixture of primacord, gunpowder and propane to create a fireball. In addition, two tightly wrapped naphthalene bombs were suspended on wires behind each flat to give the fireball an orange tint that would match the look of Viskocil's pyro. A few seconds before the explosives were ignited, stunt people protected by flame retardant clothing, earplugs, padding and fire gel started running away from the flat, reaching a safe distance before being knocked to the ground by the explosion and showered with debris made from cork and cut-up egg cartons.

As revealed through both full-size and miniature techniques, the alien attack is a devastating blow to humanity. Its aftermath is chillingly depicted by a shot of the downed Statue of Liberty lying on its side in New York Harbor with the burned-out remnants of Manhattan behind it. For the shot, a sixty-inch statue was sculpted by Michelle Molay, then filmed against a forced perspective New York City background by Doug Smith's crew. "We gave Michelle a photograph and a block of foam," stated Joyce, "and she created a terrific miniature. The painters sealed it with polyester and coated it with a penny's thickness of weathered copper to age it and make it look like the real thing."

The backdrop of destroyed Manhattan was produced using forced-perspective cutouts, photographed separately. During compositing—executed by Pablo Helman and Simon Haslett—dozens of fire and smoke elements shot against black were added, as well as a background plate of a dusk sky, a twelve-foot hero destroyer and the closing motion control schism. The water lapping gently at Lady Liberty's nose was taken from a live-action plate and displacement-mapped to simulate physical interaction with the statue. "We used that same displacement map to generate



The appearance of the alien entities sprang from two radically different concepts. One was the creature itself, small and humanoid with large head and eyes, while the other—considerably more imposing—was an insect-like, biomechanical suit worn as a protective exoskeleton.



Production designer and creature effects supervisor Patrick Tatopoulos maneuvers a rod puppet, one of several employed in wide shots of the aliens. Other approaches included cable controlled puppets and actors fitted with cable-operated appliances.



reflections of the statue on the surface of the water,” said Helman, “which really helped to tie the two elements together. It was a very difficult composite, because there were more than thirty layers that had to interact with each other; but it turned out to be a beautiful shot.”

Sculptor Tully Summers carves detailing into a full-size biomechanical arm.

Imagery revealing the aftermath of the attack in Los Angeles was achieved with a combination of miniatures and live-action photography filmed at the Fontana, California, steel mill site that had served as the backdrop for the future war segment in Terminator 2. The site was a dead ringer for a city devastated by alien attack, even before it was dressed and rigged with physical effects such as wind, smoke, debris, geysers of water from broken mains and more than a hundred propane fires. “My crew was out there rigging junked-out cars and broken fire hydrants for two weeks before we shot anything,” Clay Pinney recalled. “The biggest effect was a wall of smoke that was four hundred feet high and two hundred feet wide. We used the smoke to obscure undamaged buildings in the background, so the camera would see just what it was supposed to.”

A ten-foot-square miniature of shattered buildings, rubble, twisted cars, street lamps, parking meters and other artifacts of everyday life was built to match the look of the Fontana location, then photographed in a heavy layer of smoke within a tented stage. “We placed little flickering bulbs in the miniature to establish interactive lighting from the fires,” said Engel. “In compositing, Pablo Helman did a great job of replacing those bulbs with scaled-down fires, adding plumes of smoke to make everything look real.”

In response to the alien attack, a squadron of F-18 fighter planes is scrambled from the Marine airbase at El Toro. For an establishing shot, sixteen model planes were arranged in rows on a sheet of plywood painted to resemble a tarmac staging area. During compositing at Digiscope, Mitch Drain cloned the fighter craft to create additional rows and also added pilots—four groups of extras photographed by Peter Winther as they ran along a greenscreen strip.

In addition to the models, a full-sized F-18 mockup, built by WKR Productions, was used extensively on Independence Day, specifically for cockpit interiors involving the actors. A center-axis gimbal rig, designed by Richard Stutsman and fabricated by Clay Pinney’s effects crew, provided realistic movement on the mockup. A combination of painted backgrounds and bluescreen composites was used to place the cockpit in the air. “We shot the mockup in front of a sixty-by-sixty-foot hanging bluescreen that had already been set up,” recalled Pinney, “which posed some problems because of the maneuvers they wanted the airplanes to perform. For instance, they wanted the planes to do ninety degree turns; but we found that whenever we went that far over, we lost the key light. We ended up turning the plane only forty-five degrees. Then, behind it, we had a twenty-four-foot painted backing on hydraulics, so we could move it in the opposite direction of the plane. When the plane banked forty-five degrees left, the background banked forty-five degrees right. The result was a ninety degree turn, without losing our key light on the person inside the plane.” Other physical effects included blowing smoke to represent clouds, sparks to suggest tracers and long-duration flashbulbs.

That same in-camera philosophy was evident in some shots of the planes flying in formation. Pinney positioned five-foot, three-foot and eighteen-inch plane models behind the mockup, scaling them away from camera to create a forced perspective. “We mounted the background models on rods,” stated Pinney, “low enough in the frame so that the rods wouldn’t be seen. We had them on little gimbals so we could tilt the wings back and forth and create movement. It didn’t look all that impressive on the stage, but when we saw it through the camera, we bought it.”

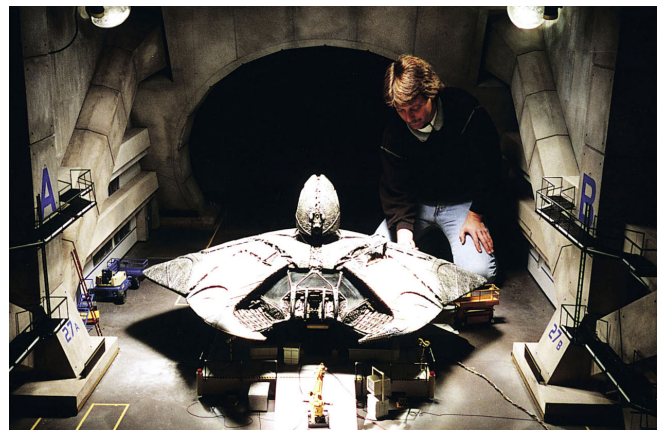
Although the in-camera method sufficed for a brief cut, the majority of the shots at the beginning of the dogfight were provided by VisionArt, a ten-year-old visual effects house that had created effects for feature motion pictures such as *Executive Decision* and had won Emmys for its work on *Deep Space Nine* and *Star Trek: Voyager*. The facility’s Daniel Kramer animated more than 150 computer generated F-18s for the scene.

Once engaged, the F-18s launch AMRAAM—advanced medium range air-to-air missiles— and Sidewinder missiles against the destroyer, only to see them explode harmlessly against an invisible shield. The missiles were sculpted in miniature by Ken Swenson, cast as hollow shells, then fitted to miniature planes or a larger-scale wing tip that was used specifically for closeups. The miniature missiles were loaded with Estes rockets, then fired from the plane models. Missile trails were computer generated by VisionArt.

In response to the ineffectual assault, dozens of attacker aircraft are launched from the alien destroyer to engage the F-18s in battle. A long, complex, high-speed dogfight ensues. Originally, the plan had been to shoot both the F-18s and the attackers as motion control miniatures, with digital models used only for background planes. The game plan changed when Tricia Ashford’s digital team demonstrated its ability to quickly produce computer generated aircraft that were indistinguishable from the physical models. “I was a skeptic until I saw the first armadas of digital planes,” Emmerich admitted. “They looked convincing, so I asked Tricia to keep going. The shots got better and better until it became very



Unmistakably a precursor to the current-day alien attackers, a UFO recovered from a 1950s crash site is studied at the top secret military installation known as Area 51. A full-size, sixty-foot-tall mockup of the spacecraft was constructed at a Hughes Aircraft hangar, transformed into the Area 51 outpost.



The captured attacker is pressed into action in a plan to sabotage the alien destroyers by planting a computer virus in the mothership that will deactivate their shields. Pyrotechnician Mickey Duff wires a four-foot model of the spaceship in preparation for a shot of its human pilot attempting a lift-off. The sequence was photographed on a miniature set built to precisely replicate the full-scale laboratory.

difficult to tell which was a computer model and which was motion control. I kept the option of going back to miniatures open for a long time; but I finally saw enough to convince me to do the rest of the dogfights digitally. Near the end, I was describing shots and then seeing them the next day- which was incredible.”

Because they intercut so well, both the motion control photography and the computer generated imagery were ultimately featured in the dogfight scenes. “Even a few years ago,” stated Ashford, “it would have been impossible to place computer generated models side by side with physical models and have them look realistic. But we now have much better tools. We can create photorealistic models, match camera moves, simulate lighting, and even add motion blur and film grain. That all comes together to make the shots look amazingly real.”

Construction of the computer generated aircraft began with one of the physical models being shipped to Viewpoint DataLabs to be scanned. The resulting wire-frame model was texture mapped by Hartmut Engel and Stefan Herrmann, using still photographs of real F-18s. While the digital models were being constructed, Ashford and her team were engaged in extensive research to help them choreograph the fighter plane maneuvers. “The attackers weren’t a concern because nobody knows what they can do anyway,” stated Ashford. “Roland told us to make them fly like a swarm of bats, so that was the look we went for. The F-18s were much tougher, because people know how they fly. We studied movies like Top Gun and Air Force training films to give our animators a real sense of how these planes should behave.” For the most complicated maneuvers, digital models were positioned over video footage taken from an Australian Air Force training film, then hand-animated in Alias to precisely match the movements of the actual planes. Benedikt Niemann also animated the alien attackers in Alias.

While individually animating each CG model was effective when few aircraft were involved, Ashford knew the technique would be too laborious for the frenetic dogfight that concludes Independence Day. “The final air battle takes place around a fifteen-mile-wide destroyer,” remarked Ashford, “and Roland wanted to see hundreds of F-18s and attackers duking it out with missiles, light balls and tracer fire. It was really an enormous challenge; and the only way it could be accomplished was through an advanced procedural system that could automatically calculate and render the interaction between all these different elements.”

Ashford found just such a system at VisionArt, where executive vice president Josh Rose and director of research and development Rob Bredow had commenced developing their own in-house particle system and compositing program- known as ‘Sparky’- when particle systems animation was first introduced. After meeting with Ashford, Rose pitched the idea of using behavior code for the dogfights. Subsequently, Bredow modified Sparky to simulate the behavioral characteristics of an aerial dogfight involving hundreds of planes and attackers. “We looked at the motion control photography and studied the animation that had already been done to determine the types of movement we would need to duplicate,” said Rose. “Then we wrote code to create realistic flight patterns and orientation for the planes and attackers so they would fly like the models, adding subtleties to make the moves look realistic.”

Once the capabilities of the planes and the alien attackers were established, Bredow and software engineers Randi Stern and Brian Hall developed a range of prioritized objectives for

each. An F-18, for example, might have the objective of attacking the destroyer, unless an alien attacker entered a zone that triggered evasive action. Rules were also established so that planes and attackers would bank away from the area where the destroyer would be composited. "We used percentages to determine such things as when each plane or attacker would pursue, evade or fire its weapons and hit its target," said Rose. "We wrote code to tie those type of events to the images that would logically follow. The impact of a missile, for example, was automatically followed by the appropriate explosion. And if Sparky calculated that a plane was hit, it showed it happening and automatically displayed geometry of a burning plane that emitted smoke and fell out of frame."

Satisfied with the interaction between spacecraft, Bredow, Stern and Hall wrote a number of controls that would enable them to set the parameters of any scene— parameters that could be changed quickly in response to feedback from Emmerich and Ashford. Near-instant modifications could be made to the overall number of planes and attackers, their concentration in specific areas of a frame, the presence or absence of alien shields, the range at which weapons could be fired, the number of missiles the planes had remaining, and the success rate of each side. "In the first battle, the action is skewed so that the F-18s don't stand a chance," stated Rose, "but in the second dogfight, the aliens get creamed. We wound up creating shots for both battles at the same time; so we'd walk into the room and ask, 'Who's winning?' The aliens might be winning on two computers, but on the other one they were getting blasted. If Roland wanted to show more attackers being destroyed or more planes being shot down, only a simple adjustment was needed because everything was automated. Making those kinds of changes by hand would have been extremely difficult. We had scenes that were several hundred frames long, with three hundred planes and attackers and all the missiles and light balls and smoke and fire and explosions that went along with that— and we were able to render them overnight. I know of no other software package that can do that."

"VisionArt had a tremendous system to begin with," stated Ashford, "and then they were able to adapt it to meet the needs of our show. I think the dogfights are a real high point in the film. The second dogfight ended up being the largest air battle ever put on film. To create that sort of action, and turn shots around in a few days, was just phenomenal."

VisionArt was also responsible for the alien ship shield effects, designed by Carl Hooper and created through a combination of Prisms 3-D software and Sparky. "Roland wanted a look unlike anything we had seen before," observed Rose. "We went through quite a few changes before coming up with a system that worked. We experimented with various different shapes, from a sphere to an ovoid. In the final version, the shield follows the general contours of the alien ship, without being an exact outline. We created that by scaling up the wire-frame and adding curvature."

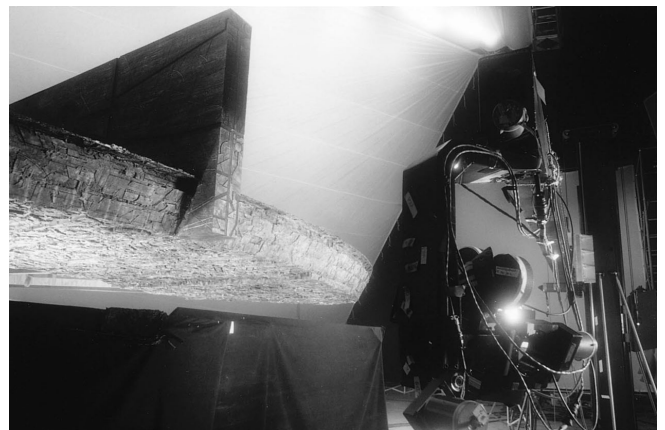
Protected by their shields, the attackers make quick work of the F-18 squadron in the early dogfight scene. To create the illusion of downed planes, motion control models were photographed, then lined up and match-moved to images of exploding pyro models. "One thing that has bothered me in films like *Top Gun*," Viskocil stated, "is that the models are stationary when the explosions take place. For this show, whenever continuity would allow it, I pointed the nose of the model toward the ground and put the tail in the air so that the explosion would go

outward and the following fireball would go upward, sweeping behind the plane and making it look as if it were moving. For some scenes we dropped the model toward the ground and blew it up in midair- which looked good but was not as easy to match to the motion control photography.”

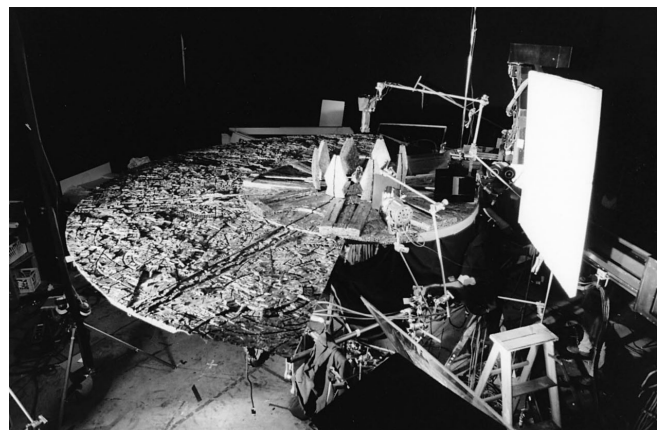
Pursued by an attacker, Captain Steven Hiller (Smith) takes cover in the Grand Canyon, dodging rock formations in a series of increasingly desperate evasive maneuvers. The shooting of aerial footage for the sequence was overseen by Doug Smith from a modified World War II vintage T-28 trainer piloted by Kevin Larosa. Unable to fly in the Grand Canyon due to permit restrictions, the plates were filmed in nearby Little Colorado Canyon with Arriflex cameras fitted to attachment points originally used for carrying external bombs. The canyon was recreated in a carved foam miniature sculpted by Steve Pinney. Set up in the parking lot of the Hughes facility, the canyon was filmed in natural light as a miniature F-18 was flown on wires between its fifteen-foot-tall spires.

In a last-ditch attempt to escape, Hiller flies his jet directly toward a vertical cliff face, then opens and releases his drag chute to obstruct the attacker behind him. Moments before his F-18 slams into the cliff, Hiller ejects to safety. The blinded attacker crashes into the lip of the canyon and slides to a stop on the desert floor. “To show the chute opening and being released,” said Engel, “we set up a miniature parachute in front of a bluescreen. An air blower was used to inflate it; then, for the release, we simply let go of the rope and let it be blown through the air.” Compositing of the shot was by OCS Freeze Frame. The action then cuts to the aliens’ point of view, filmed bluescreen by Peter Winther with a full-size attacker cockpit. On the bluescreen stage, Clay Pinney used fans and wires to pull a full-size parachute over the mockup.

Hiller’s plane impacting with the cliff face was achieved by suspending the model from a metal pole and flying it into the rock miniature at 45 miles per hour. “We knew exactly where the model was going to hit,” noted Viskocil, “and Mike Joyce had built the area around the contact point out of concrete, rather than foam, so there would be a really solid impact. I hate to see a miniature set shake when it’s hit by something.” To create the fiery concussion, Viskocil used a technique he had developed for the Seven Mile Bridge explosion in



A section of the destroyer is photographed with a motion control camera. While most shots featured a twelve-foot fiberglass hero model, miniatures were built in two additional scales, including a highly detailed sixth-scale closeup version that weighed nearly three tons.



A motion control mechanical schism is filmed for incorporation into the destroyer footage. To facilitate photography and help the mechanics run more smoothly, the model was positioned upside-down, with the camera above it. The shots were

True Lies. "I attached a cable to the rear of the plane and fixed the other end to a hook in the ground. When the plane reached the cliff, the cable pulled out a stopper that allowed two points to touch, creating a circuit that set off the explosives. It was a big improvement over impact switches, which are notoriously unreliable. Also, when you're shooting with an overcranked camera, it's difficult to judge the exact moment to hit the button. With this system, the guesswork was completely eliminated."

later augmented with computer generated energy particles, laser beams and light flares.

For the reverse angle, revealing the attacker whizzing past the exploding F-18, the ship was flown through the miniature canyon set, dressed with a mixture of cork and fuller's earth to create a more spectacular impact. The following crash-landing was created in-camera on a forced-perspective landscape. "We dressed the miniature with live bushes, ground cover that was trimmed down, shrubs from model train sets- anything we could find to get the job done," remarked Joyce. The landscape was filmed in the parking lot, surrounded by foam mountains on elevated C-stands. "The whole model was tilted at a slight angle, so the shot could be filmed against a real sky, with distant hilltops that helped to create a nice background." The attacker model- rigged by Mickey Duff and Joe Heffernan- was run up two metal rails, set up like a ski-jump, and launched into the landscape by bungee cord.

Grounded, Hiller investigates the crashed spaceship, subduing the alien pilot with an old-fashioned punch to the face. Eventually, he transports his captive to Area 51, the top-secret facility long rumored to be the site of military UFO studies. In Independence Day, the speculation proves valid, and the UFO under study bears a striking resemblance to the alien attackers. Within the vaulted research lab, the captured alien pilot is subjected to a kind of living autopsy when Dr. Okun (Brent Spiner) attempts to remove the outer 'biomechanical' spacesuit and reveal the inner creature.

The idea of an 'alien within an alien' started with two radically different designs sketched by Patrick Tatopoulos, who served as both production designer and makeup effects supervisor for the film. "One design was a small humanoid with big eyes and a big head," said Tatopoulos. "It was similar to the description given by most people who say they've seen aliens. The other design was a complete fantasy- large and threatening, with eight tentacles on its back and very narrow hips that gave it an insect quality. When I showed the sketches to Roland, he liked both of them and came up with the idea of making the larger design a kind of biomechanical suit that the small aliens wear when they travel through space."

Working with a limited creature effects budget, Tatopoulos devised a two-pronged approach for creating the aliens. Wide shots were accomplished with quarter-scale rod puppets photographed against greenscreen- with their tentacles puppeteered and filmed separately- then composited at Digiscope. Closeups were achieved by fitting actors with cable-operated appliances made of urethane. For the large creature, Tatopoulos and his team of eighteen makeup effects artists built two sets of arms, two sets of legs, one mechanical head, a full-body dummy and a variety of head and torso pieces. The small alien was a combination of mechanical full-body puppets, half-body puppets, and an oversize head constructed specifically to show reflections in the alien's eyes, made in one piece out of reflective plastic.

Because the alien had no mouth and only limited expression in its eyes, Tatopoulos had to be inventive in developing ways for it to show emotion. "The design forced us away from traditional ways of showing emotion, but I think that worked in our favor because it made them seem more alien. Underneath the clear urethane skin, we positioned twelve face plates to move the cheekbones, jaw and eyes so we could create movements suggesting the alien was aggressive or agitated or angry. We also placed computer controlled lights beneath the surface of the skin, played from a keyboard to change their intensity and create patterns based on what the alien was feeling."

After the alien murders Dr. Okun, destroying the last hope of peaceful interaction, the president orders a nuclear strike against the destroyer hovering over the evacuated metropolis of Houston. The scene required Engel to create a low-tech, inexpensive simulation of a cruise missile launch from a B-2 stealth bomber. A four-foot-tall missile was positioned vertically on a dolly, then filmed bluescreen, with the camera on its side, as it moved through manually opened bomb-bay doors. Using the Inferno, Pablo Helman and Ken Littleton replaced the blue with a background plate of Houston, created by punching holes into black cardboard. "We suggested scale by using different sized nails to make the holes bigger or smaller," stated Engel, "and added thousands of lights by applying spots of UV paint directly onto the cardboard. We created twinkling lights by simply moving the gel. It was an inexpensive solution that worked extremely well."

During compositing, Helman and Littleton added CG fire and smoke to the tail of the rocket, and slightly retimed its launch. "The forward movement was initially too slow to be believable," explained Littleton, "and the motorized dolly could only raise the model at a fixed rate, so there was no acceleration. To solve the problem, we ramped up the speed of the rocket for the last thirty frames, making it look as if it were accelerating out of the shot." As the cruise missile proceeds toward its target, the armored vehicle that will monitor the nuclear assault moves into position on a bridge- an in-camera shot accomplished by using a broom handle to push an eighteen-inch model onto a miniature bridge within a tabletop landscape. Smoke and debris blown past the model suggested the off-camera impact of the missile. When the smoke clears, the destroyer is revealed still hovering over the city, undamaged by the nuclear blast.

The future appears grim, until Levinson reasons that he can bring down the spacecraft shields by infiltrating the orbiting mothership and embedding a computer virus in its communication system. Hiller volunteers to pilot the captured alien attacker and transport Levinson to the mothership. For a shot of the attacker lifting off, a four-foot model was raised on wires within an elaborate miniature that matched the live-action set. The 'hero attacker' was detailed differently to distinguish it from ships piloted by aliens. "This attacker was supposed to have crashed in the 1950s," explained Joyce, "so we gave it some residual damage and added a different gun, as if one of the original weapons had been knocked out. We also gave it a brighter paint job because everything in Area 51 has been cleaned and sterilized. Finally we added small puppets to represent Levinson and Hiller at the controls."

Surviving armies around the world are put on notice that once the shields are disabled, a worldwide, full-throttle assault on the aliens will commence. One shot in the preparation sequence reveals fighter planes from several nations assembled in the Iraqi desert. The

background plate was filmed at a dry lake bed, with three full-size wooden mockups of a MiG, an F-18 and an F-15. This small air force was multiplied a hundredfold by Jennifer German at Pacific Ocean Post, who duplicated and composited a variety of miniature elements. On a twelve-by-twelve-foot platform, Engel and his crew positioned miniature planes, tents, vehicles, oil drums and other scaled dressing provided by Mike Joyce. By exchanging decals and other markings on the planes, Engel was able to quickly shoot three different miniature setups, all in the same light.

The fate of the world resting on their shoulders, Hiller and Levinson pilot their alien craft into the mothership through a long triangle-shaped tunnel. To enable Jim Balsam to move his motion control camera through the supposedly enclosed environment, a twenty-four-foot tunnel miniature was built in sections, with hinged doors every two feet to allow passage of the motion control rig. "We always shot in one direction," stated Smith, "so we simply reversed the end piece to reflect whether they were moving toward the mothership or away from it. Roland wanted the scenes to be dark and mysterious, so we used a 15mm lens— which made the model very difficult to light. There weren't any recesses in the model to hide light sources, and we couldn't light it from the ends because it would have been visible. We ended up punching holes in the model to create these intense shafts of light. To render the model bright enough, we had to use thousand-watt-hour lights that tended to melt the model. It was a very painful sequence to film; and I have to give thanks to Richard Sands, the gaffer, and Mark Rommick, the key grip, for their great problem solving."

Making the photography even more difficult was the precise timing required in raising the hinged doors to allow passage of the motion control rig. If raised too soon, the camera would pick up the additional light source; too late, and the camera arm would bump into the ceiling of the miniature. To further complicate the sequence, six alien transports and four attackers— each a separate motion control element filmed in three passes— were also maneuvering through the tunnel as the hero attacker entered.

Hiller and Levinson finally manage to infiltrate the mothership. The most challenging aspect of photographing the interior scenes was establishing the vessel's scale. "The ship was supposed to be incredibly huge," remarked Doug Smith. "But everything inside it was unfamiliar alien



The virus successfully implanted, a worldwide aerial attack is launched against the now vulnerable alien destroyers, with the President of the United States himself leading a squadron of F-18s. A shot of the planes— flying in formation as their cruise missiles are fired— featured a motion control model in the foreground. Background F-18s, missiles, engine fires and smoke trails were all digitally rendered by VisionArt.



Responding to the attack, alien aircraft engage the fighter planes above Area 51. Pacific Ocean Post composited pyrotechnic effects and a miniature destroyer onto a live-action plate of the RV refugees scrambling to safety. Also included in the shot were computer generated attacker planes, ray beams and attacker fire, all animated by the ID4 digital unit.

technology, so there was nothing to establish the scale except the attackers, which we had already seen. We tried to choose angles on our hero attacker that would help create a sense of size, but it was an uphill battle. Our basic approach was to keep everything dark and mysterious- and hope that the imaginations of our viewers would do a lot of the work for us.”

The mothership’s principal architectural features were enormous columns, hundreds of miles in length. Built as twelve-foot-tall miniatures, the columns were arranged on stage and photographed in heavy smoke by Smith, Harry Alpert and the motion control crew. “We built one full column and two half columns that were three-dimensional,” stated Mike Joyce, “as well as two flat photo cutouts that were used as background elements. The 3-D columns were carved out of two-tone foam. Making the molds was a tremendous job because each one required almost a hundred gallons of RTV rubber. After painting the columns, we added miles of fiber optic lights to them.”

Within the mothership, a long line of alien soldiers is revealed boarding a transport ship. For this initial shot, the aliens were represented by a single quarter-scale rod puppet filmed against greenscreen as four puppeteers maneuvered it to walk up a ramp. The action was photographed six times, with subtle changes in movement implemented for each repeat. At Pacific Ocean Post, those six elements were composited into a motion control plate of the staging area and transport. For a higher angle that establishes the transport as just one of many, distant aliens were computer generated at VisionArt.

The hero attacker finally locks into a docking bay attached to a gantry. In a wide shot, thousands of such gantries are revealed, extending far into the distance. At Matte World Digital, Paul Rivera digitally repeated two miniature gantries several times until they receded into the distance. The cloned element was then combined with a digital matte painting rendered by Chris Evans. “Oliver Scholl provided us with some production paintings to help us determine the look of the final composite,” stated Matte World Digital visual effects supervisor Craig Barron. “We were given two miniature elements of gantries with attackers on them- one with two attackers, and another with one. Paul duplicated those and used digital cut-and-paste techniques to create new gantries with different numbers of attackers so that he would have more options when he scaled and positioned them in the composite.”

Evans created a preliminary low-resolution version of his matte painting using Photoshop, then switched to Liberty 64- a paint system developed by Chyron- to blend his digital artwork with photographic elements. “The matte painting was the glue that held everything together,” stated Barron, “because it filled in the gaps that would otherwise have required an enormous miniature. Chris has an astute eye for detail, so he was able to look at everything that had already been shot in the mothership and paint a new area with the right amount of detail and atmosphere.”

Having uploaded the virus that will immobilize the shields, Hiller and Levinson deliver a parting gift to the mothership- a nuclear missile. Rigged by pyro crew members Tom Zell and Bob Ahmanson, the missile is seen shooting through a corridor and flying past startled aliens before finally slamming into a wall and lodging in a command post. “We filmed the launch of the missile in closeup with a two-foot model that was pulled out of a tube with a bungee cord,” said

Engel. “We added pyro flames to the back of the rocket practically; so we were able to finish the shot with only a wire removal. We used the same bungee rig to show the rocket flying through two miniature corridors. We also composited a motion control missile for two shots of it flying past aliens in wider areas of the ship.” The aliens in the shots were cable-controlled head-and-torso puppets that Tatopoulos and his team animated against a greenscreen. A video assist setup was instrumental in timing one alien’s movements so that its head would turn as the missile whizzed past.

Shots of the missile’s impact were achieved with a four-foot model rammed through a breakaway wall. The event transpires in the cortex of the mothership– a tiered amphitheater where hundreds of aliens coordinate the invasion and follow its progress on large display monitors. The cortex was created in just two days by Conny Fauser, who used the Flame to combine and manipulate elements that had been shot for other scenes. The monitors within the cortex were lifted from live-action photography within the full-size attacker cockpit. Four full-size head-and-torso puppets were puppeteered in front of a greenscreen, then digitally replicated to place hundreds of moving aliens at consoles.

The reverse angle, looking from behind the wall into the nose of the missile, was filmed within a full-size control booth set built by the model shop. “We’d built everything else within the mothership,” said Joyce, “so we were already familiar with the shapes and textures and paint work. It made perfect sense to have us build the control booth. Even though it was full-size, it was still kind of a miniature because it was scaled to the aliens, who were only a few feet tall.”

The destruction of the mothership was revealed in a series of digital effects produced at VisionArt. “There was an obvious comparison that was going to be made with this effect,” Tricia Ashford observed. “So we started by asking ourselves, ‘How do we make this different from the explosion that destroyed the Death Star?’ After exploring a number of options, the solution we came up with was to create a digital model of the ship and use computer generated effects to break it into pieces, as if a very rapid chain reaction takes place inside it.”



The mothership’s human infiltrators deliver a parting shot in the form of a nuclear missile. Views of the giant spacecraft in orbit were filmed motion control with a twelve-foot stationary model. Upside-down and partially completed, the miniature reveals a pattern of holes designed to berth tiny four-inch destroyers.



Doug Smith and his crew prepare a motion control pass on a section of miniature set representing the massive mothership interior. With little means of establishing scale, Smith opted to shoot interior scenes in low light, relying on select camera angles to help create a sense of size.

“We started with a CG mothership based on the model,” Josh Rose elaborated. “That was rendered and then broken apart in Prisms. As the cracks enlarged and spread, white shards of light- also rendered in Prisms- became visible. Finally, there was a huge explosion and, in a series of frames, the mothership dissolved into particles- an effect accomplished using Sparky.” A dramatic side view revealed a wall of debris- created with Sparky and Prisms- overtaking the hero attacker, generated in Prisms alone.

The shields disabled, earth’s beleaguered survivors mount a massive aerial battle against the aliens. To achieve images of missiles hitting their unprotected targets, blasting the enemy ships to pieces, foreground explosions were matched to motion control elements and computer generated models. Missiles launched against the larger destroyers, however, create only small, ineffectual surface explosions. With few missiles remaining, and the hope of destroying the alien ship diminishing, crop duster pilot Russell Casse (Quaid) makes a desperate and noble move, deliberately flying his F-18 into the destroyer schism, triggering a massive explosion that disables the vessel and brings it crashing to earth.

As originally filmed, the sequence had Casse piloting his crop dusting biplane into the schism, as opposed to an F-18. After getting feedback from test audiences- who didn’t buy the low-tech assault- the scene was changed and the biplane was digitally replaced with a computer generated F-18. A problem that resulted from the last-minute revamping of the scene was that the explosion of the plane when it impacted with the destroyer cannon was now far too modest to suggest the full-force impact of an F-18. A more dynamic explosion was called for- but, unfortunately, Joe Viskocil’s pyrotechnics unit had long since left the production. The CG team came up with the solution of taking the massive explosion of The Empire State Building- seen earlier in the film- and inverting it. Pacific Ocean Post then composited the modified explosion imagery over the destroyer cannon.

The subsequent crash of the alien destroyer was revealed in a digital combination of pyro elements filmed against black, a destroyer model, and a sky background plate filmed by Philipp Timme in the Hughes parking lot. Utilizing a video dub of the background plate as reference, Anna Foerster shot the destroyer with a motion control move that dropped the ship at a forty-five-degree angle, seemingly toward hills in the background plate. At Digiscope, Mitch Drain worked on the Domino to combine the separate beauty, lighting and smoke passes, using the matte pass to composite the destroyer into the background. He then added separate fire elements and rotoscoped the hills to place them in front of the destroyer so that the ship’s actual impact with the ground would not be revealed. The crash was merely suggested by debris, digital camera shake, and explosions along the leading edge of the ship.

In mid-May, just weeks before the film’s release, Viskocil and his team were recalled to stage huge, full-scale pyrotechnics that would augment the destroyer crash sequence and shots of the exploding schism. “We came in for one week to do these incredibly large, gasoline-type explosions,” recalled Viskocil. “I had thought all along that they would need some explosions of that scale. Even after those shots are reduced down, all the detail is there.” The full-scale explosion elements were reduced and composited at Digiscope.

Having discovered the destroyers' Achilles heel, the American troops relay the information to fighters around the globe. The success of their counterattack is established in a series of digital matte paintings rendered by in-house digital artist Michael Lloyd and combined with photographic elements to reveal downed destroyers in Sydney, Egypt and East Africa. On the Cineon compositing system, Lawrence and Ken Littleton matched Lloyd's paintings to each background plate, and added fires, smoke and a distant dogfight rendered by VisionArt. The final shot in the sequence- the triumphant return of Hiller and Levinson to Area 51- included a matte painting of a downed destroyer that was composited with a live-action plate by Peter Sternlight at The Post Group.

Fittingly, Independence Day concludes with a dazzling display of 'fireworks' as debris from the decimated mothership penetrates the atmosphere. The effect was realized by VisionArt. "Roland wanted the effect to look more like fireworks than an actual meteor storm," remarked Josh Rose. "We created it in three layers- high-altitude fireworks that are barely visible, mid-level fireworks that establish the transition as the pieces break into a random series of smaller trails, and low-altitude fireworks that build in intensity, size and speed." Using Sparky, Rose and colleagues established rules to govern the behavior of the fireworks at all three altitudes, determining how many frames a piece of debris would linger, the altitude at which it would break apart, the number of new fire trails that would be formed, and the length and color of each trail. "We used a decay mechanism to create smoke that would linger and dissipate after the debris burned out. It ended up being a very difficult effect to create, because Roland had a specific look that he wanted, and we had to make the fireworks visible against an overexposed blue sky."

With the film completed, Engel, Smith and the entire visual effects team finally had the opportunity to celebrate their independence and, with the benefit of hindsight, assess the singular experience they had shared. "The biggest lesson I took away from Independence Day," observed Engel, "was that you need at least three months of preproduction before you start shooting effects on a film of this scale. We only had five weeks, and that made everything that much more difficult. There are always a few shots that you classify as CBB- 'could be better'- but I think we were able to balance those with some very strong effects. I'm more proud of the range of effects we created than any single shot. There are lots of one-dimensional effects films, where the same technology is used over and over. We constantly had to invent things, and that made the job exciting."

In part, that excitement stemmed from the atmosphere of experimentation that had permeated the production as Roland Emmerich and Dean Devlin attempted to prove, once and for all, that creating visual effects independently and in-house is a promising alternative to outside effects contracting. "Building our own effects teams and having everything together made a big difference," reflected Emmerich. "It helped break down the departmental way of thinking that you get on a lot of films, where the production and visual effects crews hardly talk to each other. I like working with a crew, not a lot of separate units. When you break down those boundaries and get all that talent and experience pointed in the same direction, some incredible things happen."

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Cruising the Digital Backlot

article by Mark Cotta Vaz

The image of a train, whether being boarded in a station or steaming through rugged countryside, has been a familiar one in the movies ever since the 1895 release of *Arrival of a Train*, a moving picture that reportedly had audiences ducking in their seats to dodge the seemingly oncoming engine. Other memorable movie train moments followed, such as the aging outlaw band hijacking a locomotive in *The Wild Bunch*. Alfred Hitchcock made masterful use of the tight quarters of a moving train in *Strangers on a Train* and *North by Northwest*. In the modern movie era, with its capacity for jaw-dropping spectacle, trains have been used to set off explosive action sequences, such as those in *The Fugitive* and *Under Siege 2*.

Industrial Light ... Magic lays claim to a few train scenes of its own. For *Out of Africa*, the opening title sequence of a train chugging through the African wild was created as a bluescreen miniature composited into background plates shot in Kenya. In *Back to the Future III*, the tale's wild west action included bluescreen locomotive elements and shots of a quarter-scale train flying off a miniature trestle and crashing into a ravine set. For *Mission: Impossible*, a Paramount Pictures release directed by Brian De Palma, ILM was called upon to create the ultimate in train-centered action sequences.

Based on the CBS television series of thirty years ago, *Mission: Impossible* is the latest entrant in the parade of old TV shows to reach the silver screen. In the series—now familiar to a new generation of viewers via cable access—a tape-

image



In *Mission: Impossible*, director Brian De Palma and actor Tom Cruise—in a dual turn as both star and producer—put a modern spin on the popular sixties television series about a top-notch team of secret agents renowned for their clever, high-tech stinging operations.



To accomplish a daring daylight finale in which Cruise, as IMF agent Ethan Hunt, and traitorous senior agent Jim Phelps struggle atop a speeding bullet train headed into the English Channel tunnel, Industrial Light ... Magic employed a refined blend of digital and miniature trickery. Effects art director George Hull and effects supervisor John Knoll confer over conceptual art and blueprints for the sequence.

recorded message relayed the week's assignment to Impossible Mission Force leader Jim Phelps, played by Steven Hill in the show's first season, and later by Peter Graves. The tape would then self-destruct, and the dynamic Lalo Schifrin theme music would trumpet acceptance of the mission. Whether targeting a Latin American dictator for overthrow or frustrating the schemes of the Soviet Politburo, each week the multitalented and multifaceted IMF team would flummox its foes, then drive away at show's end, having pulled off another high-tech sting.

Set in the present, the big-screen Mission: Impossible could not help but deviate from those glory days of secret agents and Cold War intrigues. The film opens with IMF agent Ethan Hunt (Tom Cruise) involved in a disastrous mission in which he is fingered as a mole. In a shocking twist for fans of the old show, senior agent Phelps (Jon Voight), presumed dead in the fatal mission, is revealed as a traitor who faked his own demise in order to sell vital information to an unscrupulous arms dealer. Hunt, on the run and desperate to clear his name, eventually tracks Phelps to a bullet train where the turncoat agent consummates his traitorous dealings. Phelps' brazen getaway plan has him climbing to the roof of the train where a helicopter will drop a rescue cable and spirit him away. His escape is foiled when the tenacious Hunt climbs topside to pursue his former comrade and mentor. Atop the bullet train- which is speeding first through the French countryside and then through the recently unveiled English Channel tunnel at more than 250 miles per hour- Hunt and Phelps engage in a battle to the death. The suspense is heightened when Hunt attaches the rescue cable to the train, dragging the pursuing helicopter into the tunnel where it ultimately 'self-destructs.'

As conceived by De Palma and Cruise- who also served as producer- the climactic action was to be a spectacular seven-minute sequence staged in the unforgiving light of day with the stars themselves clearly visible atop the high-speed train. Given the dangerous nature of the sequence, the only reasonable approach was to have Cruise and Voight perform on a bluescreen train set, then composite those bluescreen elements atop a computer generated train moving within virtual environments. Even the getaway helicopter, originally intended to be shot practically for the exteriors, would become a CG element throughout. "When we met with Brian De Palma and Tom Cruise," noted effects art director George Hull, "their goal was to have the train sequence top other action sequences in terms of speed and excitement. By creating it in a digital environment, we could place the actors in dangerous situations that would otherwise be impossible."

At the helm for ILM was visual effects supervisor John Knoll, whose decade with the facility began with a 1986 assignment as effects camera operator for Star Tours, a Disneyland simulator ride. In the late eighties, Knoll and his brother Thomas created Photoshop, the high-end image processing software that has become an invaluable graphic arts tool for both publishing and motion picture visual effects. For Mission: Impossible, Knoll and his team would not merely be producing disparate elements and individual shots, but would have command of the entire train action sequence.

Bluescreen elements of the actors were shot at Pinewood Studios in England on the so-called '007 Stage,' a huge soundstage built originally for the James Bond epic, The Spy Who Loved Me. The stage had an expansive, 35-by-140-foot bluescreen backdrop, with a coved corner and second leg that ran an additional 80 feet. The practical and detachable full-scale train cars upon

which the actors would clamber, grapple and dangle were constructed of wood and fiberglass, and extended a full 100 feet when laid end to end. The train set could be configured with a 35-foot-long detachable baggage car, while the main 65-foot-long car could be detached into two separate sections. For a handful of shots, in which actors would be composited onto computer generated cars, the performers would interact with train set pieces covered with bluescreen material. The illusion of motion would be provided with speeding background plates, CG train and tunnel animation, postproduction camera shake and other visual cues.

In addition, there would be a major interactive touch to provide the illusion of speed on stage— a 140-mile-per-hour wind blasting the actors. To create the practical effect, the production first experimented with jet engine prop fans— an option quickly discarded because of the dangerous kerosene fumes emitted into the closed soundstage environment. Ultimately, the production opted for stationary parachuting fans used by jumpers for free-fall practice. “The system had a throttle to control different amounts of wind velocity,” Knoll stated. “We also augmented some of Tom’s closeups with off-camera compressed air blowers aimed directly at his face. The actors took a lot of abuse from that wind. I stood in it a few times; and at that force, your hair goes straight back, your skin ripples, and it’s almost impossible to stand up.” The high-speed wind was so strong, the crew had to hardback the bluescreen to prevent it from flapping. But as problematic as the wind was, it was used to advantage in several shots, including one in which Cruise’s character lets loose his grip in order to slide quickly down the train to catch Phelps just as the traitor is being picked up by the helicopter. In addition to being pulled on a wire atop the practical set, the athletic Cruise used the wind force to aid his slide and even perform a flip in the air.

To provide interactive illumination on the actors, the tunnel was designed with racks of repeating overhead lights for use during the bluescreen shoot. “When compositing the scenes into the CG tunnel months later,” George Hull commented, “we could marry the environment by timing those interactive lights to the live-action plates. The intervals of lights rushing past the camera also provided a dynamic sense of depth and speed.”

For more naturalistic lighting, the train set was temporarily moved outdoors to the Pinewood backlot to be photographed in daylight. The resulting footage, featuring a Cruise stand-in atop the set piece, provided the effects artists with invaluable lighting and color references for the outdoor scenes. Given the image processing demands, any morsel of data was welcome. “This show had some of the most complex color corrections and lighting management issues I’ve ever encountered,” noted CG supervisor George Murphy. “Our background footage contained widely varying terrain, shot under different weather and lighting conditions over several days. We had to conform each of these shots so that when strung end to end they would appear to represent one continuous moment. By itself, that was a serious challenge. Compounding it was the problem of adding foreground bluescreen elements, shot indoors on a stage. The lighting was designed as much to make the actors look good as it was to match environmental conditions. To realistically match the foreground with the background, while still retaining the ‘beauty’ lighting, required some complex solutions that went way beyond basic color correction.”

The bluescreen elements were composited into computer generated environments, model environments or background plate photography shot in Scotland in Spring 1995. For pure

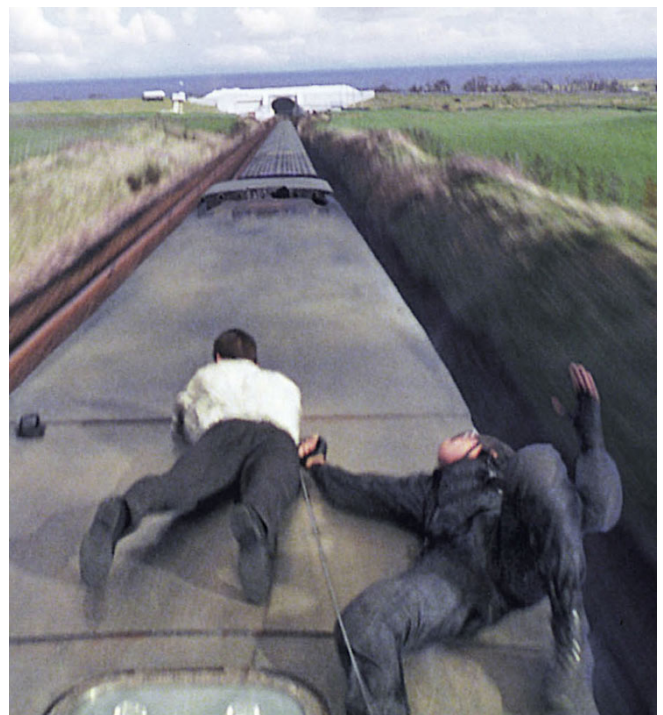
cinematic value, the production had opted to photograph the plates on a sixty-mile stretch of railroad track that meandered north from Dumfries, a town near an inlet of the Irish Sea, to Kilmarnock, near Glasgow. From the air there was a visually pleasing curve to the lay of the track through the countryside, as well as such sights as an old stone bridge that would ultimately figure in an establishing shot of the train. A straightway section of road near Dumfries- with a motorway bridge and grassy embankment- was deemed perfect for shooting a plate that could be transformed digitally into the English Channel tunnel entry.

Much of the photography was captured from a twin-engine helicopter manned by Knoll, second unit director Eric Schwab and freelance aerial plate photographer David Nowell, who operated a Wescam gyro-stabilized mount on the copter exterior. A third of the plates required views from the helicopter, while the other two-thirds- with views down the track- necessitated a camera mounted to the rear car of a train on location. For the aerial views, the formula for simulating bullet train speeds of 250 miles per hour and upwards was to fly the camera helicopter at a minimum of 80 miles per hour and undercrank to 12 frames per second. The formula worked well when shooting empty tracks into which bluescreen and CG elements would later be composited; but when the practical NOTAR- for 'no tail rotor'- helicopter was added into the mix, the plate photography became more complicated. "We'd always planned on a CG copter for the tunnel interior shots," Knoll explained, "but we thought we could use a real one for the exteriors. For shots looking back down the length of the track, we originally intended to shoot at 8 frames a second or so, to get the ground rushing past, then do a soft split in the sky where we could put the real helicopter, shot at 24 frames per second. That proved to be a naive approach because the location track was almost never straight. Plus, our own camera copter couldn't get close enough, or get the angles we wanted, because of the radius of the blades and the safety distance we had to maintain."

The turning point that took ILM down the path to creating an all-CG helicopter was a side view of a real helicopter dropping the cable that Phelps



Images of the bullet train hurtling through open countryside featured bluescreen elements of the actors composited atop a train that was entirely computer generated. A getaway helicopter- originally planned as a live element for the exterior shots- also ended up a digital creation when shooting with a real chopper proved impractical.



As the two agents grapple, the speeding train approaches the tunnel entrance. Foreground elements were photographed bluescreen with Tom Cruise and Jon Voight performing on a full-scale train car mockup erected on stage at Pinewood Studios. Cars further up the track were computer generated. The distant tunnel entrance was rendered as a 3-D digital matte painting by Paul

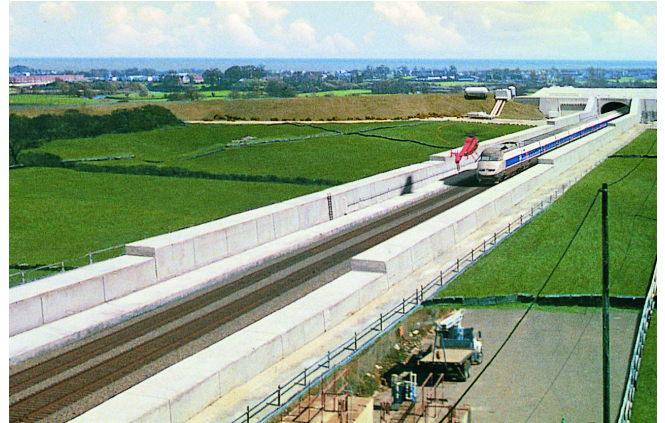
would be seen reaching for in the final composite. “We flew our camera copter at 100 miles per hour, and I undercranked to 20 frames per second,” Knoll said, “but the image was jerking around too much. Since we couldn’t get away with undercranking, we cheated the side view by photographing the real helicopter at 24 frames per second- but the ground was still only going by at 100 miles per hour. I figured we could put some CG trees in the foreground to make it look like the ground was rushing by faster- but Brian De Palma didn’t buy that. The solution was to switch to one of our other background plates, in which the ground was going by faster, and put a CG copter into it. It was the failed attempt to get any of the other helicopter plates that forced us to make a CG helicopter that would look good in a daytime environment- and it ended up being a better shot.”

The practical NOTAR photography provided a perfect reference for the CG crew. The synthetic helicopter was modeled in Alias, animated in Softimage and rendered in RenderMan, with lighting and shading provided by ILM’s own ‘ishade,’ a breakthrough interactive lighting tool the company had first developed for Jurassic Park. “With the computer generated copter we could get the motions exactly the way we wanted them,” said George Murphy. “We also had control over the lighting and all the fine details of how different elements interacted with one another. In CG we had the freedom to do God’s-eye-view shots and other angles that would have been extremely difficult to get with a real copter.”

Also computer generated was the bullet train, modeled after a French TGV, the national supertrain. But, while the building of the CG helicopter had been aided by practical footage, there was no unambiguous reference of a real train in the background plates to guide the modeling, animation and lighting of the CG train. “You’d think that the train set would have provided some matching reference,” Murphy commented, “but to make sure we didn’t have any problems with blue spill, those set pieces had been dulled down, with sunlight and other environmental reflections added during the compositing.” Not only was the train built entirely as a CG model for some shots, others featured computer generated cars that were added onto the practical train set.

Shadows, directional highlights and ambient lights on the CG helicopter and train were handled by associate visual effects supervisor Joe Letteri. Hailing from a CG background, Letteri had become a specialist in shader issues at ILM, assisting in the development of the isshade package. For Mission: Impossible, Letteri prepared a major rewrite of the in-house shader software,

Huston. / The train nears the tunnel with the helicopter- tethered to it by a rescue cable- trailing close behind. In a wide establishing shot, the train, helicopter and tunnel approach- all digitally rendered- were composited into a digital matte painting derived from background elements photographed in rural Scotland.



The train nears the tunnel with the helicopter- tethered to it by a rescue cable- trailing close behind. In a wide establishing shot, the train, helicopter and tunnel approach- all digitally rendered- were composited into a digital matte painting derived from background elements photographed in rural Scotland.

combining it with RenderMan. “Basically,” Letteri explained, “RenderMan is the engine and isshade is the tool to tell the renderer what to do. RenderMan is a programming language that can be used to describe all the physical aspects of light and light interaction. You don’t always want to leave those choices up to the renderer, however, and you want to have control over where the tradeoffs are. Because it’s an interactive lighting tool, isshade gives us that control.”

Another compositing tool- ‘icomp’- was utilized to subtly blend the elements by taking background colors and dissolving them into the foreground bluescreen images. “The icomp software allowed us to make multilevel color corrections that were once impossible,” George Murphy stated, “adding color contamination that integrated the elements. That was critical on this movie because the entire sequence had to match. We didn’t have the same issue inside the tunnel because we were creating that environment completely in CG. But it gave us more control for the environmental changes in the outdoor photography. For 3-D elements, such as the copter and the train, we could do environmental maps and real reflections. These blending techniques got us beyond color correction and matching issues, and helped the bluescreen foreground elements conform to the plates.”

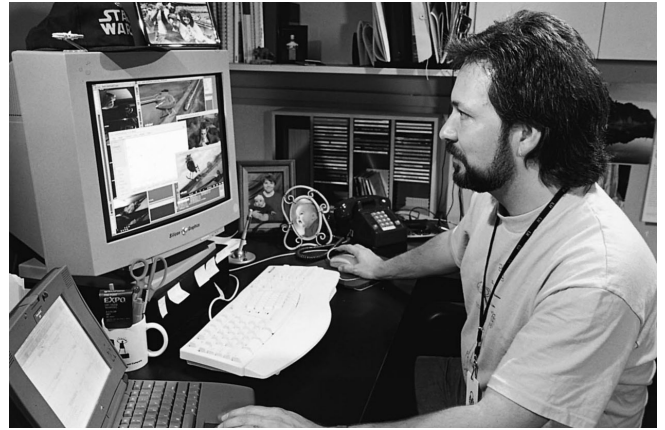
While such innovative techniques helped marry the various elements, achieving the look of breathtaking speed required the adding of motion to the locked-off bluescreen and copter photography. “A big part of the action look we were trying to create came from giving the camera in the scene some extra motion,” Murphy observed. “Once we added camera shake and the sensation of buffeting wind, the difference was amazing. Everything seemed to be happening twice as fast.”

"We wanted the sense of the camera as audience," Letteri added, "to bring people into the scene as if they were physically on the train. There's a sense of danger going on around you, and the feeling that the cameraman is going to get that shot, no matter what. He may shoot from a bouncing train mount, standing between train cars with the camera on his shoulder. It's the Hitchcock style—but updated, with a train that is moving close to 200 miles per hour."

Lens flares and other photographic effects added polish to the scenes. "Lens manufacturers labored for years to get rid of lens flares and artifacts," Murphy observed with a laugh, "and now we're doing our best to add all that stuff back in. It's become part of the language of film. If lens flares aren't there, we think something is amiss. Of course, it has to be done with a light touch; but virtual environments have to have these little handles to suggest to the audience that there's a camera interacting with the environment."

All of the compositing work for Mission: Impossible was divided between the CG department and another team working on the Sabre— a real-time system, developed by Lucasfilm during production of its *The Young Indiana Jones Chronicles* television series, that can accept both in-house and off-the-shelf software. Shots featuring complex 3-D elements stayed in the CG department, while more basic two-element comps were relegated to the Sabre. "We can turn certain shots around much faster than in CG," noted Sabre operator Rita Zimmerman, "but the Sabre is better suited to straightforward composites, without a lot of elements. It requires a different approach on the part of the production. Our streamlined user interface and fast hardware requires faster decision making."

This wide array of digital tools allowed De Palma to ask for, and receive, entirely new shots on short notice. One such shot was the only establishing view in the entire sequence— a wide boom shot of the speeding train crossing a bridge as Hunt battles to catch up to Phelps. Halfway through the shooting of the bluescreen elements, De Palma decided to replace the shot with an entirely new view to open the sequence. In addition to the original boom shot of the bridge and a CG train, the new segment would include an already completed live-action push-in on a train compartment window where, behind half-closed blinds, Phelps could be seen assembling a gun.



Digital effects supervisor George Murphy reviews several of the composites produced for the sequence.



No miniatures were used for exterior views of the train approaching the tunnel entrance. However, for a few essential scenes inside the tunnel—including a spectacular helicopter crash—miniatures were deemed essential. Model shop project supervisor Steve Gawley applies set dressing to an eighth-scale section of tunnel constructed for the explosive finale.

While it would make for a dramatic establishing scene- the camera flying down out of the sky to come abreast of the moving train and move in on the window- there were problems matching the background boom shot and the live-action push-in. "We had to create a seamless transition from the background plate to a four-perf production plate that wasn't originally intended to be an effects shot," Knoll explained. "But the background plate to which we'd matched our CG train only lasted about eight seconds, and we had fourteen seconds to fill before we moved completely off the ground to the push-in on the window element. So we inserted some CG trees going by, just before we ran out of ground underneath the train. Then we completely transitioned from plate photography to computer graphics ground and replaced the sky with a painted element for that missing six seconds. That allowed us to run the shot until we got up to the window." In Hitchcock fashion, Knoll digitally inserted the image of himself behind a compartment window adjacent to Phelps' in the final shot.

Eventually, scenes of the train speeding through open countryside give way to its approach to the tunnel entrance. The escape helicopter following the train into the tunnel was one of the movie's key action sequences. An early concept- quickly discarded as being too contrived- had the pilot suddenly seeing the tunnel entrance looming dead ahead, forcing him to fly inside. The winning idea was to have Hunt hook the rescue cable to the train. Thus tethered, the pilot has no choice but to follow the train into the tunnel.

Taking a great deal of dramatic license, the film features a tunnel entrance bearing little resemblance to the actual English Channel link that opened with much fanfare in May 1994. "Leading up to the real entrance, there's flat ground excavated for a long ways, with embankments that gradually come down to the roadbed, and a flat white wall," noted Paul Huston, who would help create the tunnel entrance and surrounding landscape with a digital matte painting. "For our version, the production wanted the entrance to be high off the ground so the characters would be able to see it in the distance as the train approached. There would be maybe an eighth of a mile of field and concrete walls on both sides of the tracks."

In addition to Huston's digital matte painting, the final shot incorporated elements of sky and road photography snapped in Scotland and beachfront photography to represent channel water. "At the beginning of the shot," explained Huston, "the painting is on the horizon, so it's barely changing. But as it gets closer and closer, it presents more of a blending problem. At the end of the tunnel entrance approach, we had a combination 2-D and 3-D shot with concrete bunker walls that were modeled and rendered to match the motion of the plate. The painting itself was texture-mapped onto a plane that was matched to the walls." Key to Huston's approach was the use of models as an image foundation. He carved the tunnel entrance out of a strong, but lightweight, foamcore material; then, to attain reference footage, placed the sixteen-foot-square tabletop miniature outdoors and photographed it at various angles in natural sunlight.

To determine his lighting, Huston relied on the background plate into which the tunnel entrance would be composited. "I always start with the plate because it has the camera angle, as well as the direction and type of lighting," said Huston. "Part of the retouching I had to do was for the lighting. The Scotland sky was filmed in springtime and had this beautiful, diffused look, while the model was filmed in California during bright, crisp, sunny autumn days. So I had to get the model's light values back into the plate's range."

The entrance approach incorporated a bluescreen image of Phelps hanging onto the side of the train as it roars into the tunnel. The train, the helicopter and the cable were all computer generated; and the surrounding landscape was comprised of background plate and painted elements. The CG department was given the responsibility of creating the match-moves for all the elements. Using the wide camera shot, Greg Killmaster found an acceptable focal length in Softimage that would accommodate the entire painting- assembled from images shot with different focal lengths. Jon Voight, filmed climbing on a bluescreen mockup of the train at Pinewood, was extracted and positioned atop the CG train by Tom Rosseter and Mike Conte. The final shot was composited with subtle touches such as interactive shadows from the whirling copter blades cast on the tunnel entrance.

A few weeks before the movie's release, ILM returned to the tunnel entrance shot at the request of Tom Cruise, who felt it could stand some enhancement. Knoll added an active dolly camera move and transformed the 2-D painted elements into a three-dimensional environment. "The final shot is completely synthetic," Knoll said, "a 2-D/3-D hybrid with Jon Voight composited into the scene. Marc Cooper reanimated the original camera pan and tilt on the matte painting to complement the new dolly move- which meant re-rendering every element in the scene with the new move. Since the higher POV also meant the move would extend to the right side of the tunnel, Paul Huston added more sky and landscape. I then built a 3-D model and projected the painting onto that geometry. Because of the new 3-D camera move, we also had to remove any 2-D objects in the original painting that stuck up from the surface- such as telephone poles, fences and trees- and make them three-dimensional. The change from a 2-D to a 3-D matte painting added enormously to the realism of the shot."

The design of the tunnel itself was worked out by George Hull, who was given a free hand by production designer Norman Reynolds. "The challenge of the CG tunnel was to overcome the problems of most digital environments," said Hull, "which are too clean, exact and stiff. As the art director- and working closely with Joe Letteri- I tried to include the imperfections of realism in every part of the tunnel aesthetic."

Everything within the tunnel interior- with the exception of the actors- would be fabricated, from the computer generated train and tunnel to the miniature tunnel set where the explosive finale would be staged. Since the computer generated and model shop tunnels would have to match, the two departments shared information as their respective representations evolved. While the model shop was crafting fifteen eight-foot-long tunnel sections, Joe Letteri's crew took reference photos to aid in the building of their digital model.

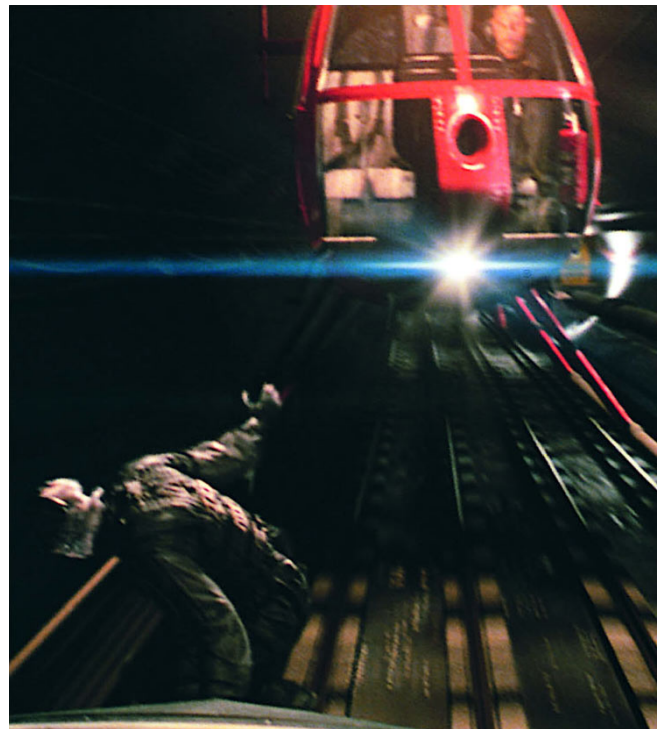
Scale would be an important factor when modeling the computer generated tunnel. "We cheated the scale to keep it tight and claustrophobic," Hull explained. "The actual scale of the computer graphics tunnel was so small that if a helicopter tried to fly through it, the blades would never clear the walls. Building the tunnel in CG you have so much control, you can scale it down as you need to, without having to rebuild as you would a physical miniature. When we had built the CG model it looked great, but the size still didn't feel right. So we went back and added recognizable, human-scale things such as service utility sheds and ladders. They fly past the camera, and you might not notice them, but the environment would look sterile if they weren't there."

A particularly difficult color correction and lighting issue came early in the sequence, with agent Hunt dangling from the side of the train and staring into the lights of an oncoming train. The shot was especially complex since the CG crew had to account for the interactive touch of a special headlight rigged underneath the camera during the bluescreen filming. "There was supposed to be a constant color brightening on Tom's face as the train comes toward him," said Murphy, "but the light on his face ramped up from a deep orange-red at the beginning of the shot to its intended yellow-white at the end. The lighting change was further complicated by a regular flashing light intended to represent passing tunnel lights. We ended up having to animate the shifting orange color out separately for the highlights, midtones and shadows on Tom's face, using a series of tonal extractions and animated rotoscope mattes."

While Hunt manages to pull himself out of the path of the approaching train, more death-defying challenges await. By now the cable is free from the train and Phelps has leapt to the copter skids. Hanging onto the skid, Hunt slaps an explosive device onto the helicopter. With the ensuing explosion, the action transitions to the model shop's version of the tunnel. The eighth-scale tunnel model was built, painted and detailed by a crew of twenty-two, headed up by model shop project supervisor Steve Gawley. Assembled, the five-foot-wide, three-foot-tall model featured two separate tracks, running some 110 feet. The miniature was designed so that a third of the oval-shaped tunnel could be removed for lateral shots, while views up and down the track could be accomplished with the sides closed. From the wild side of the tunnel, modelmakers, stretched out on wheeled carts, could move down the length of the track to apply set dressing touches such as laser-cut aluminum details and black thread stapled in place to suggest wiring. The miniature was set up



Inside the tunnel, Hunt clings precariously to the side of the speeding train. Footage of Tom Cruise on the full-size lead car was photographed bluescreen at Pinewood and later incorporated into a CG rendition of the tunnel and remaining section of train.



Phelps attempts a daring transfer to the helicopter—whose pilot, finding his craft cabled to the train by Hunt, had no choice but to follow it headlong into the tunnel. The shot was achieved by compositing bluescreen elements of Jon Voight—also the cockpit interior and pilot—with computer generated elements of the tunnel and helicopter exterior. Lens flare and other effects enhanced the final composite.



in the ILM backlot and shot at night so the light of day would not complicate filming when the set was open for side views.

As an explosive device planted by Hunt detonates, the helicopter veers into the tunnel wall. The fiery sequence was staged entirely with miniatures and shot high-speed using a special sled rig to propel both helicopter model and camera along a 120-foot length of track.

The crash scene included a side view of Hunt being blown through the tunnel by the blast and landing back on the bullet train, with the blazing copter wreckage tumbling behind him. For the practical element, Cruise was suspended from a wire rig on the bluescreen stage at Pinewood and flown at 15 miles per hour. To impart the proper effect, the actor flayed his arms at half-speed to correlate with the final speed Knoll would attain by skip-printing the shots. "I wanted to make it look plausible that he's being blown through the air by the explosion," Knoll explained, "to make it look fast, but not comically fast. At the point of his impact on the train, we stop the skip-print and go back to real time." Skip-printing required Knoll to take into account the interactive lighting on the bluescreen element of Cruise. "The overhead lights in the soundstage ceiling fired off in sync with the camera shutter being opened on particular frames. I had to program different sequence patterns to simulate different speeds of travel. There was one pattern at 24 frames per second and another for the skip-printing portion. That way, the lights would appear to be going at the same rate, instead of looking as if everything had slowed down."

The exploding helicopter- which dispatches Phelps and his pilot accomplice- impacts on the tunnel ceiling, severing the train's power system. Hunt, stranded on the decelerating train, can only watch helplessly as the tumbling helicopter hurtles towards him, its rotor blades still spinning. The sixteen-shot sequence of the explosion and its aftermath required special camera rigging, pyro effects, eighth-scale model helicopters and a like-scaled train nose section upon which Cruise would be composited.

For the model helicopter and camera rigs, mechanical effects supervisor Joe Fulmer proposed a monorail and slot gag that would connect with the tunnel set. The basic setup required two separate four-by-two-foot sleds underneath the set- one for holding model helicopters, the other for mounting a camera shooting high-speed, eight-perf photography. The surface platforms for the copters and cameras were set on half-inch-square vertical steel posts that extended up from the respective sleds through a two-inch slot set between the miniature tracks. The camera itself rode on a track platform that also carried batteries for the Wescam high-speed camera unit, an 8mm video camera and monitor, and a train nose model for the final shots. For side views, Fulmer's crew prepared an outrigger track system- fashioned from four-inch aluminum tubing- upon which the camera could be mounted to travel along with the model.

To match the 200 mile-per-hour speeds of the computer generated portion of the action, the copter/camera sled rig was propelled at fifty-five miles per hour by a pulley system that sent it rocketing through the 120-foot set in just two seconds. Getting everything up to speed required an additional 400 feet of track in advance of the set, with another 100 feet at the end to allow the sleds to slow down after passing through. "The cable made a big circle to the lead camera sled and then went around and attached to the model sled," said miniatures director of photography Martin Rosenberg. "We fought constantly to keep this thing at a controllable speed. We had a safety person positioned at the end of the track with a mechanical lever that

could be used to apply the brakes if something went wrong. We were dealing with microseconds at those speeds; and on the actual set floor, the clearance on each side was as little as a quarter inch.”

Initially, the miniatures were to be photographed with ILM’s lightweight, high-speed Empireflex, built more than a decade ago for *The Empire Strikes Back*. Although the film crew shot for about a week with the classic camera, it was ultimately replaced. “At first,” commented Fulmer, “it was figured that having the carriages moving at 55 miles per hour and shooting at 72 frames per second would allow us to match the speeds of the CG part of the tunnel sequence. But then it was decided to go 120 frames- and *The Empire* only goes 72 frames per second. That meant going with a Wilcam, which had batteries that, unlike *The Empire*, could not fit underneath the set. They had to ride on the camera carriage itself- and, thankfully, the set was just big enough.”

The practical speeds of the model/camera platforms made the objective lens of a video camera a vital part of the shooting setup. "We relied totally on that video tap," Rosenberg stated. "We needed an immediate sense of what we had so we could make adjustments for subsequent takes. Some days we might do up to five takes. It always took almost an hour to get the camera back, do all the trips, redo the pyro. I was constantly pushing Steve Gawley to give us more helicopters." To cover the production demands, some two dozen eighth-scale copters were built out of epoxy glass and then covered with foil to provide a metallic look during the pyro events. Rotor blades were powered by electric starter motors used in radio controlled planes and the skids were cast from lead so they would crumple upon impact.

Pyro damage to the models ranged from blasted cockpits to shattered helicopter pieces strewn along the tracks. "Restoring the tunnel was no problem," Gawley noted. "To prepare for the next take, all we had to do was clear out the copter debris. We could leave the crash marks caused by the copter and pyro because we were flying by them so fast they weren't noticeable. We were shooting at night until three or four in the morning, sometimes almost to the magic hour near dawn. Before I went home for a little sleep I'd leave a pile of broken helicopters out for John Goodson, Jon Foreman and Kim Smith to rebuild during the day shift. We were literally working on the copters 24 hours a day."

Requirements for the scene would have the helicopter models exploding at high speed while a special pneumatic mount launched the burning wreckage down the tracks. Pyrotechnic expert Geoff Heron was concerned with synchronizing the explosive charges, which ranged from a powdery mix of gunpowder and titanium for sparks to a combination of gunpowder and plastics material for a fireball effect. The pyro action



The helicopter fuel tank ruptures and ignites, triggering a massive explosion. Pyrotechnic charges supplied the initial blast and fireball, while a pneumatic launcher mount catapulted the tumbling aircraft wreckage toward camera.



The force of the explosion hurtles Hunt through the air and back onto the bullet train. To accomplish the effect, Tom Cruise was flown-suspended from a wire rig on the bluescreen stage- with the resulting footage skip-printed to speed up the action.



began with the helicopter's window cracking, then flames in the cockpit dispatching the pilot, followed by ignition of the gas tank. Three switches on the helicopter sled hit trips on the track that would trigger the pyro events, coupled with nearly a dozen spark switches, mounted to the track and tripped by the speeding cart.

The exploding helicopter and flying debris were composited behind the actor, and the skip-printing was discontinued once he made contact with the foreground train set piece.

The model was rigged with a pneumatic launcher mount- built by modelmakers Scott McNamara and Eben Stromquist- to literally catapult the helicopter forward towards the camera and then retract backwards into the track slot and out of camera view. For the opening side shot of the copter explosion, the model was launched up into the roof of the tunnel set. On impact, breakaway rotor blades were timed to blow off, accompanied by pyrotechnic spark effects. For final shots featuring the copter wreckage smashing into the rear of the slowing train- with Ethan Hunt pinned on the upper half- a special rig was designed to hold together a copter model and the eighth-scale nose section of the bullet train. At the appropriate moment, an air ram was rigged to slam the copter into the train model, with the rotor blades whirling closer and closer to the throat of the hero agent, who would be safely composited in later.

For final closeups, three-inch-wide aluminum blades were attached to a stepper motor and photographed motion control. The action required a seamless match between the spinning model rotors created on the miniature set and the final motion control rotors. Cruise, who had been filmed draped over a train nose covered in bluescreen material at Pinewood, was composited atop the fiberglass model.

The bullet train sequence- from its establishing view of the the train speeding through the countryside to its concluding shot of rotor blades spinning to a stop just shy of Ethan Hunt's throat- had a final count of 150 shots. The mini-movie-within-a-movie was indicative not only of the dawn of virtual sets, but of the growing artistic partnership between effects artists and filmmakers. The digitally composited sequence reflects the evolving nature of what was once regarded as a purely postproduction function. "Effects are becoming a more integral part of the filmmaking process," stated Joe Letteri. "Instead of providing isolated impact, digital tools can be used to carry a story through- which is a big leap."

"This show was an inversion of our normal process of taking live-action plates and putting in believable computer generated objects," John Knoll concluded. "In Mission: Impossible, we took bluescreen elements of actors and put them into believable CG backgrounds. This use of bluescreen actors and completely synthetic environments is likely to be used extensively on the next Star Wars movies, which will have sequences set in fantastic environments created solely as digital matte paintings or computer generated images."

The Mission: Impossible train sequence might well be remembered as the forerunner of the Digital Backlot. And with ILM seemingly on the twin paths of creating both computer generated characters and totally virtual environments, there is the prospect and promise of more impossible shots to come.

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SPLIT PERSONALITIES

article by Janine Pourroy

The final days of the twentieth century are not going out with a bang, nor even the predicted whimper. They are going out with a blur. Our lives speed by as demands bark incessantly from dawn's groggy rise until we stumble into bed at day's end. The longing for time- more time, quality time- has become the prevalent fantasy of the nineties, a fantasy well considered by filmmaker Harold Ramis, a writer-director known for reaching into the collective unconscious and delivering its contents to audiences in hilarious and insightful morsels. With *Multiplicity*, his latest offering, Ramis explores the modern myth of a man so fragmented by life's abundance that he resorts to an innovative and desperate strategy of time management- he has himself cloned.

The richly versatile Michael Keaton plays Doug Kinney, a devoted husband and father who is torn between the diametric demands of job and family. Striving to be everyone's everything has left Doug exhausted and overwhelmed. As if in answer to his prayers, Doug encounters Dr. Owen Leeds (Harris Yulin) of the Gemini Institute, who tells him: 'I make miracles. I make clones.' The solution of creating 'Two,' a duplicate of himself, suddenly makes sense- and promises to give Doug Kinney all the time in the world. A later visit to the institute brings forth 'Three,' Doug's fully-realized feminine self, who picks up the domestic slack for his wife, who has just returned to her career. Ultimately, Two and Three also find themselves



In *Multiplicity*, the idea of cloning as an antidote to the frantic pace of modern life was given a comedic spin by director and co-writer Harold Ramis. Michael Keaton starred as overworked Doug Kinney, who undergoes cloning to produce Two- the ultimate on-the-job helpmate.



A working relationship that dated back to *Ghostbusters* made visual effects supervisor Richard Edlund, and his Boss Film Studios, Ramis' first choice to provide the production's hundred-plus effects shots. To accommodate the complex split-screen photography that would achieve the multiple-character illusion, greenscreen setups,

overworked and decide, without Doug's knowledge, to clone 'Four' who, like the copy of a copy, is not quite as sharp as the original.

state-of-the-art video assist, motion control, and an on-set digital compositing system, developed by Boss, were all employed during the first-unit shoot.

Ramis was introduced to the Chris Miller short story- also entitled "Multiplicity" - in 1992 while directing Groundhog Day. Though intrigued by the premise, he found the story's resolution- wherein the clones turn on the main character and push him out of his own life- to be less than satisfying. Ramis let the story percolate for a year or two, until he was struck by the potentiality of a more philosophical turn. "The cinematic possibilities were tremendous," Ramis recalled. "Having four versions of the same guy walking around was clearly a great concept for a farce. But I always look for a deeper connection in what I do; and it occurred to me that the story was not just about not having enough time. It was really about the divided self. We are all torn in different directions; but it's not because of external demands, it's because of internal fragmentation. We are several people, and we want to go different ways because of the different personalities we harbor. It occurred to me that the division in this character broke down very conveniently along archetypal models that are well defined in psychology and mythology. There's a deep masculine self, an inner feminine self and an inner child. It wasn't the whole tarot deck, but it seemed like a reasonable place to start."

Ramis suggested to Chris Miller and Mary Hale- at work on a first draft of the Multiplicity screenplay- that they give their tale the more Jungian spin. Later, he joined them as co-writer, along with Lowell Ganz and Babaloo Mandel. The picture went into preproduction in January 1995, with Ramis on board as producer, together with Trevor Albert and co-producer Whitney White. Lee R. Mayes acted as executive producer for the Columbia Pictures release.

Early tasks included detailed storyboarding- essential given the complicated logistics of the story. "In the beginning," said Whitney White, who served as effects liaison for the film, "it would take us half an hour just to figure out how Doug was going to get across a room. Was he going to go in front or behind Two? Which clone was going to pass the couch first? We didn't quite know how it was all going to work. We had storyboard artist Marty Kline working with us in the initial phase, and he helped us determine what was possible. Later on, Peter Mitchell Rubin took over, drawing storyboards directly on the computer. The storyboards were our guidelines, the blueprints that told us where to start, if we could afford it, and whether a shot could reasonably be attained within our time frame."

The most immediate problem the filmmakers faced was also the most obvious: how best to multiply Michael Keaton times four? They appreciated the inherent difficulties an actor must face with any given role- and knew that coping with four roles simultaneously would complicate the challenge exponentially. Another imperative was that the visual effects technology responsible for creating the four-character illusion function unobtrusively on the first unit set. To maintain continuity for the cast and crew, and ensure consistency of the images, the filmmakers decided to confine the effects work- more than one hundred shots- to a single facility. "The effects had to be seamless," noted White, "and they had to look alike. We knew our biggest compliment would be if nobody said a thing about them. That kind of consistency and quality control would have been very hard to maintain if we'd spread the job out. The production had to work as one voice, one effort. Moviemaking is already a cacophony of voices;

it made sense to keep those voices to a minimum.” To that end, the producers turned to Boss Film Studios and Academy Award-winning visual effects supervisor Richard Edlund, whose enduring cinematic contributions ranged from the Star Wars films and Raiders of the Lost Ark to Batman Returns and Species– and whose maiden project as founder of Boss Film had been Ivan Reitman’s Ghostbusters, which Ramis had co-starred in and co-written.

Ramis presented Edlund with his parameters. He wanted to shoot Multiplicity as if he actually had four Michael Keatons, without sacrificing its comedic energy to cumbersome effects techniques. “Richard was sensitive about devising a system that would allow Michael to be free to do comedy within it,” Ramis commented. “As dazzling and perfect as we wanted the visual effects to be, that sense of freedom was the most important element. We didn’t want to put Michael in a straitjacket or nail his feet to the floor and force him into repetition that would work against his spontaneity. Richard was very aware of that. He made it possible for us to treat the technology as a wonderful toy, as opposed to a monster we had to satisfy.”

Edlund concurred with the approach. “Harold does a beautiful job with comedy,” Edlund noted, “but he knows how to pull at the heartstrings, as well. His movies are a full experience. It was important to come up with a technique that would allow him to do his job without the encumbrance of taking four hours to set up a motion control camera, or some other awful interruption. We wanted to provide a comfortable and flexible system that would make the effects as invisible to Harold as possible. It was also important to work in tandem with the director of photography, Laszlo Kovacs, another old friend from our Ghostbusters days.”

Though still involved with Species, Edlund and crew began preparations for a new system that would meet Multiplicity’s stringent production demands while achieving the convincing duplication of the film’s star. Edlund met with his director of research and development, Shahril Ibrahim, to discuss the possibility of devising a digital compositing system that could deliver a rough composite on the set within minutes. “We’d been playing around with that idea for a while,” remarked Ibrahim, “and it seemed to have a lot of potential, but we didn’t have a system completely in place at that point. Richard told us about Multiplicity, and said that Harold Ramis would be coming to see the system in one week’s time– and could we have it ready to show him? Gautham Krishnamurti and Hiroyuki Miyoshi and I worked on it during every spare moment we could find. What we came up with was a prototype system that could instantly composite one video input with a previously recorded pass.” The software engineers were still tweaking the system the day of the compositing demonstration, making last-minute adjustments even as Harold Ramis arrived. “When Harold and Richard came onto the stage, we had our fingers crossed behind our backs. We hadn’t had a chance to thoroughly test the system; so when we pushed the button, we didn’t know if it would work or not.” Fortunately, the prototype did work, providing the software designers with a solid foundation upon which to build a more complex system for use on set.

Upon the completion of Species, Ibrahim, Krishnamurti and Miyoshi turned their concentrated efforts to developing Multiplicity’s digital compositing system. Their strategy was to use two stock Silicon Graphics Indigo 2XE workstations equipped with Cosmo and Galileo input and output boards. The first SGI would be employed as a player, while the second would composite together one pass from a video tap recording the current action with a digitized image from a

previously recorded pass. A digitized audio time code was employed to precisely synchronize the separate film passes- an essential element since any fluctuation in timing, even by a fraction of a second, would have made a flawless composite impossible. The system was also capable of generating instant greenscreen composites and split-screens with articulate animated rotomattes.

“If we had done the effects for *Multiplicity* in a traditional manner,” commented Ibrahim, “we would have filmed Michael Keaton with a double, and then had them switch places for the second pass. But for every pass, Harold would have only been able to see what each layer looked like- not the combined element. Our system allowed Harold to look at the monitor during the takes and see the composite. That was critical to the timing, position and attitude of every scene.”

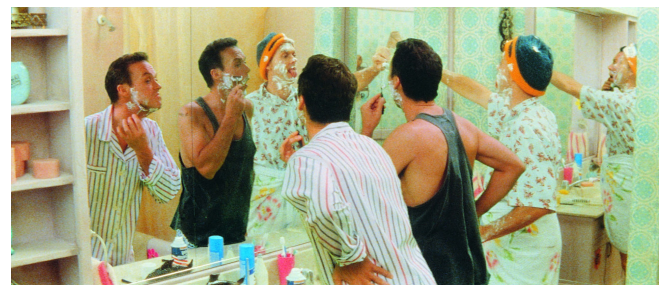
It was evident from the start that maintaining accurate and consistent eyelines would be essential to establishing the reality of the multiple clone premise. Keaton’s eyes would have to connect precisely across an imaginary plane with one, two or three invisible characters, appearing to lock eyes on screen with his clones. Without this connection, the authenticity of the effect would be invalidated. “Before we started using the on-set compositing system, the eyelines couldn’t be clearly determined,” said Edlund. “We could tell that the characters were looking in the same general direction; but when we actually looked at the two pieces of film together, if the eyeline was off as little as three inches, it was evident. The audience would have been aware that something wasn’t right.”

After an intensive three-month period of development and testing, the multiple compositing system was installed into a large, comfortable trailer that could be moved from location to soundstage with relative ease. In addition to the customized SGIs, the trailer was fitted with a special air conditioning unit to neutralize the high temperatures generated by the computer equipment. A large umbilical cord linked the trailer to the set, and provided a conduit for communications, telephone lines, video in-and-out feeds and power lines. Several miniature surveillance cameras were installed at strategic locations on the set, with a video monitor enabling the trailer-bound engineers- Ibrahim, Krishnamurti and Miyoshi- to maintain visual contact with the first unit.

Because the producers wanted to be prepared for every possible contingency, the multiple compositing system represented only one among an array of filmmaking tools provided by Boss.



The workaholic Two is soon joined by Three- a sensitive, domestic type- and the childlike Four. In an early scene, all three clones are observed shaving together. Garbed as Four, Keaton was photographed first on a full bathroom set. The same green set was used for Keaton’s depiction of Three.



Overlapping mattes were required to composite each character’s image- and his multiple reflections- into the scene.

The effects company would also employ a motion control camera to effectively replicate passes—a crucial element of Ramis' four-actor approach. "All of the shots were motion controlled in one way or another," explained Edlund. "Even the so-called locked-off shots had motion control and follow focus. We ended up with a system that could be set up very quickly and, in fact, looked like a normal camera dolly— it just had more wires coming off of it. We would rehearse a scene until Harold was satisfied, and then the operators would program the dolly with the desired move."

Another tool devised by Boss was a motion control laser tracking system that would mark the path of the actor as he moved around on the set. Mounted on a device similar to a rifle scope, the laser beam would be aimed at Keaton to track his movements during the first pass. After those moves were encoded, a small fiber optic scanning system would project laser graphics onto the floor or walls during the second pass, precisely delineating the actor's original blocking for reference. Because the laser beam ran in sync with the camera during the shutter-closed cycle, it could be seen clearly by the people on the set— yet would not be picked up on film. The same tool was used occasionally to scan small reference points for Keaton to focus on.

Particularly ingenious was a hand-held video playback system that would serve as a 'character' for Keaton to play against on the set. During filming of a scene, a stand-in for the actor— usually Skip Stellrecht— would videotape Keaton's 'A' performance from the position of the 'B' character in the first pass. Then, during the second pass— with Keaton having changed costumes and transformed into the 'B' character— the stand-in would hold on his shoulder a video monitor that played a recording of the 'A' character's previous performance, all the while tracing the blocking originally executed by Keaton during the first pass. "With Michael playing to his first performance on the video monitor," said Edlund, "he knew exactly what his facial expressions were. He knew his timing and his pauses and his position. Additionally, Harold would be watching a composite of the first part combined with the second part on the video monitor— so he could tell how the interaction was working. You couldn't really watch the scene as it was happening on stage because you'd see the stand-in, and that could be confusing; you had to watch the monitor and look at the composite, which was being done on the fly, in real time."

A time-coded sound system was also an integral part of the process. To avoid the distraction of Keaton's hearing the double's voice mixed in with his own dialogue after a take, the double's lines were removed from the audio recording by sound engineer Peter Brancaccio using a Macintosh-based Pro Tools system. Brancaccio worked concurrently with the multi-comp team— either at a station adjacent to the SGIs in the trailer or just off-stage for better visibility— and was ready with the edited sound tape by the time the rough visual was completed. Keaton wore a flesh-colored 'earwig' to receive his own radio-transmitted dialogue, recorded during the preceding pass. "The Pro Tools system functioned in a way analogous to the SGIs," said Ibrahim. "The SGIs handled the imagery; Pro Tools handled the audio. It would capture every pass on separate tracks, digitally, and play out the composite sound for Keaton to hear in his earwig. Between passes, Peter would go through the sound; and wherever he heard the double, he'd squelch it down so he could play Keaton's own voice back to him. Everything tied in— the audio, the video, the motion control and the laser. At one point we counted fifteen monitors and ten computers on the set. It looked like a NASA space mission."

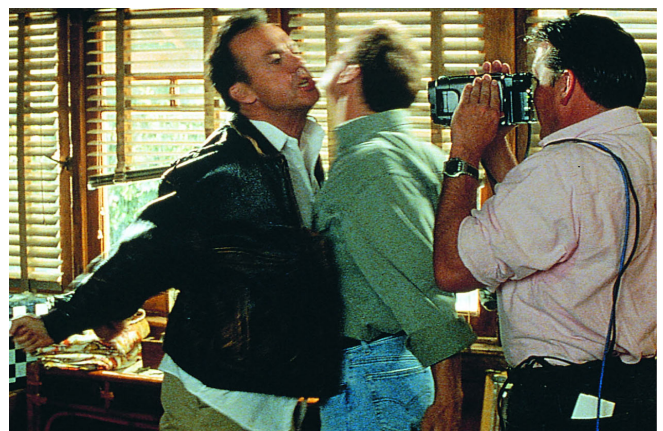
Finally, Boss provided a variety of setups for greenscreen photography, used throughout *Multiplicity* in lieu of the bluescreen so popularly employed in traveling matte work over the years. "Green is a much better color to use because you don't need as much light," explained Edlund. "It's in the middle of the spectrum, so the lens is better corrected for it. As a result, mattes fit much more closely. For the most part, we used foamcore pieces painted with a digital green paint that Jonathan Erland mixed in half- and one-stop-down increments for us- although we did use his digital green cloth for a few scenes. Frequently, we rigged a piece of green foamcore that was just big enough to conceal Michael and produce a matte where he crossed over. For example, he would start out on the set in the first plate, cross over into a greenscreen area, and then walk back onto the set. That way, we could get the shot using a combination of split-screen and greenscreen, as opposed to all greenscreen. Even though we can pull excellent mattes these days using digital technology, we still try to do splits when we can because a fully green set is disorienting to actors." Partial greenscreens were also useful in avoiding troublesome color contamination and other problems ensuing from large-scale screens. By positioning a green card just behind a character, a small transparent window was created in which to place him. "Huge screens can cause more problems than they solve; and I've always eschewed using them. I generally prefer to put a little screen behind a specific actor and move it around- as opposed to these great big expanses, which cause nothing but green or blue spill all over everything."

After nearly eight months of preparation, production began August 28. Various locations throughout the Los Angeles area were chosen for the filming, including Pasadena- where the Kinney house was situated- and the architecturally striking Skirball Institute in the Sepulveda Pass, which doubled for the Gemini Institute. A digital matte painting by Michele Moen enhanced establishing shots of the site, placing the landlocked building high atop the cliffs at Malibu.

At the Skirball location, Boss' customized trailer and multiple compositing system were first put to the test for a shot in which Dr. Leeds' own identity as a clone is revealed. "It was a very important shot," stated Edlund, "because it was the first time the audience was going to see a clone in *Multiplicity*. Like the opening shot of *Star Wars*, if the audience wasn't grabbed by the reality and drama of the premise, we would run the risk of losing them. It had to be really perfect. As soon as we started shooting the footage involving Dr. Leeds, however, everything that could go wrong did. It was our first time out and we ran into some



Doug and Two celebrate their partnership with a boisterous chest bump.



major programming snags– although production wasn't aware of them. There was a lot of very sophisticated program modification going on in the trailer, unbeknownst to the crew. It was a trial by fire, but it turned out great."

After some location hopping, the multi-comp trailer arrived at Sony Pictures Studios, where both interiors and exteriors of the Kinney home and garage apartment had been constructed on Stages 15 and 26. With the effects trailer just offstage, CG supervisor Brian Samuels worked directly on the set, determining how the mattes would be cut and trouble-shooting various shots and camera setups. He maintained constant contact with the production, either through the trailer or the video tap, and communicated with plate producer Seth Tamrowski whenever adjustments were mandated. "We were delighted by how much Harold Ramis and Laszlo Kovacs allowed us to be involved in shooting," noted Samuels. "We had a very strong voice in the way the film was shot because it was such an effects dependent movie. We've worked on movies in which the director of photography wouldn't allow a CG supervisor on the set while he was shooting. It is very difficult to get the best possible results under those conditions." Edlund also remained on the set, conferring with Ramis and Kovacs on a shot-by-shot basis.

The unusually close collaboration between the effects and camera crews was reflected in the fact that both effects footage and principal photography were shot anamorphic, using similar Panaflex cameras. Early on, a question had been raised concerning the optimal film stock for both principal photography and effects purposes. To satisfy his stringent lighting requirements and produce the best looking film, Kovacs chose to use a fairly fast stock– a decision that caused a few concerns within the visual effects team. "It was wonderful to be able to use a production camera and not have to rely on our big Vistavision cameras for any of the shots," Edlund allowed, "but we did have to make some concessions with the film stock to satisfy everyone's needs. Laszlo liked the look of Kodak 5296, so we used that when we were doing splits. But whenever we shot greenscreen, we chose Kodak 5298– which gave us a better green matte– later balancing it to the look of the '96."

The intimate, interactive presence of visual effects on the first unit set was like the meeting of two previously segregated and exotic cultures; but after the initial strangeness wore off, the collaborative results were overwhelmingly positive. "In the beginning," noted Ibrahim, "first unit was a little wary of us, I think. But after the first or second day of showing them what we could do, they were very accepting; we all became part of the same team. Part of the problem in the beginning was nomenclature. The first day of testing, Harold, Richard, Michael Keaton and the visual effects crew got into a discussion of how best to accomplish a specific shot. At that point, nomenclature wasn't fully worked out– nor was how to refer to Keaton and his various characters. Because of the complexity of all of that, the conversation got pretty bizarre. Harold and Richard were referring to Keaton, saying, 'Doug One does this and Doug Two stands there'– and it was really comical. The conversation was just like the story, where confusion ensues

The chest bump was first photographed with Keaton, dressed as Two, acting opposite a double who would ultimately be replaced in the frame. To provide crucial reference, Two's performance was videotaped from the approximate position of the second character. The 'Doug' side of the shot was then filmed on a greenscreen stage, with Keaton executing the chest bump against a stand-in dressed in a green suit and hood. Precise alignment and interaction were finessed during the compositing phase.

because of all these multiple characters. At the end of it, someone tagged me and asked, 'Did you get all that?' I said, 'I thought you did.' Fortunately, Richard and Harold seemed to have understood it, so we just followed their leads."

Confusion on the set was kept to a minimum through the use of clone stand-ins. Keaton's longtime stand-in, Dimitri Moraitis, played opposite the actor most frequently and- possessing hands and arms closely resembling Keaton's- was called in whenever such appendages were to be featured on screen. Moraitis alternated with Silas Cooper, who worked particularly well as the gentle and effeminate Three. Career stuntman David Thompson was adept at capturing the generic goofiness of Four, and stood in opposite Keaton whenever that clone was required in a scene.

For the more complicated setups, Ramis relied on the stand-ins, the effects crew and the carefully worked out storyboards to orchestrate the logistics of a scene, holding fast to his commitment to approach the photography as if he were shooting two, three or four different actors, as opposed to only one. "We blocked the scenes as if we were just making normal shots in any movie," Ramis observed. "Our obligation was to carefully choose our shots so that we would really score with the ones we decided to do. We had a wonderful first assistant director, Michael Haley, who understood that there was a kind of geometry about it, and who designed the shooting schedule so that Michael Keaton would have as few physical makeup and costume changes as possible- and also fewer psychological adjustments. We were on the set for almost six weeks with just Michael alone, going from one character to another."

Haley worked with Whitney White in conducting the elaborate symphony of costume changes, set placements and camera angles. "Some of the scenes were long and complicated," recalled White, "and we had to figure out the shooting order so that Michael wouldn't have to change every ten minutes. We put all this information into an incredibly thick manual that we showed to everybody- 'We've got to shoot it this way and do it in this order!' As we gained experience, we were able to relax a bit. Everyone knew what the parameters were- from Harold down to the grips- and that created the opportunity for a lot of spontaneity."

Naturally, the more characters featured in a given shot, the greater its complexity. "Blocking became crazier when more clones were involved," remarked Brian Samuels. "The hardest part was simply the amount of time it took to incorporate three or four characters. To shoot one forty-five-second take, Michael Keaton had to go through three complete costume changes- which would take two or three hours. Then, for each take we had to do several passes. It could easily take an entire day just to do one short scene."

One of the most important considerations in planning the day-to-day production schedule was the order in which the different character passes were filmed. "Because we were compositing in real time," related Ibrahim, "the order of shots was vital. Either the background character would have to go first and the foreground second, or the foreground character would lead the action. Sometimes that conflicted, because we always wanted the leading character to drive the timing of the scene. If the leading character was going to drive the scene, but he was in front of another character, we'd have to use a greenscreen. Every shot had to be worked out based on who the dominant character was and which layer he would be in."

If, for example, the dominant character was the one in the background, the cameraman would simply shoot the action and layer the subsequent character passes over the first. But if the dominant character was filmed during the second or third passes- towards the foreground of the shot- the filmmakers had to carefully calculate the other characters' positions and greenscreen those areas. The dominant character could then be shot first to set the timing of the scene, with the other characters composited in accordingly. "We discovered that, most of the time, one character's performance was the key to the other performances," stated Edlund. "That wasn't a problem, because each scene was worked out so well during rehearsal. Harold wasn't limited by having to pre-record everything. He could do as many takes as he wanted until he got a performance to build the rest of the scene on."

Particularly intricate was a party sequence in which Two and Three invite a couple of girls up to their apartment. There, Doug is introduced to Four for the first time. The scene- which required meticulous choreography and forty-two separate costume changes- had a final running length of six-and-a-half minutes and boasted twenty-six visual effects shots, the most of any scene in the film. Another sequence has Doug coming upon his clones shaving in the apartment's mirrored bathroom. Achieved through clever use of greenscreen photography, the shot featured four Michael Keatons and a dozen clone reflections. "It doesn't come across as an effects scene at all," commented Edlund, "but the sequence had to be filmed in a bathroom that was completely green- with the exception of Michael's initial performance that took place within the actual set. The other performances were shot after we covered everything in green. The mirrors were reflecting green, too, so we had to do mattes for each character and at least one reflection for each character."

A greenscreen-dependent shot revealed earlier in the film has Doug and Two doing a celebratory, NBA-style chest bump. "Shooting the chest bump required Michael's stand-in to be fully decked out in a green suit with a green hood," recalled Ramis. "Coming out of this strange green man was Michael's voice, recorded on the tape track and played back. It looked as if Michael was engaged in conversation with some bizarre superhero- Greenscreen Man- who was talking in Michael's own voice. It was absurd."

With all the high-tech accouterments and visual wizardry available to Ramis on the set, it was Keaton's unique ability as a performer that was ultimately responsible for the success of the effects. "Michael Keaton is a very skillful actor," said Ramis. "He's smart and he's physically coordinated, which were very important assets. Multiplicity required him to develop the poise of



After Doug breaks up a rowdy party in the clone's apartment, Two expresses his displeasure by blowing smoke in his original's face.



On the set, Edlund positions a hand puppet at the appropriate height to guide Keaton's eye-lines as he performs the first segment of the shot.



For the second segment, Keaton as Doug was photographed in front of a greenscreen. To ensure the accuracy of his reactions and timing, the actor played the scene against a video monitor, on which

an athlete, with the ability to remember where he was supposed to be at any given moment. We would rehearse on set and work out what each

his previously recorded performance as Two was replayed.

character was going to do, while leaving Michael a lot of freedom to overlap himself, to interrupt himself, to upstage himself. We really trusted our improvisational skills. It was great to be able to examine all the possibilities right then and there- and then be able to get the shot."

"Michael Keaton became the greatest composite actor in America, and should be awarded as such," Edlund affirmed. "He really got into it and knew how to play against himself- and then play against a third and, sometimes, even a fourth version of himself."

Keaton's physical skill and impeccable sense of timing are showcased in an early scene. "From a technical standpoint," said Ramis, "one of the most delightful moments in the movie is the scene in which Doug introduces his second clone to the first clone. Doug sticks his head in the door and the first clone offers him a beer, pulling a can off a six-pack on the table and tossing it to him. When we laid down the 'A' side of that shot, the stand-in threw the beer to Michael, positioned at the door to play Doug. Then, when we did the 'B' side, Michael played the part of the first clone and he threw the beer to a stand-in. The Boss crew was fully prepared to do a CG beer can flying through the air, because we all thought it would be impossible to exactly match the action of the can from one pass to the next. Yet, somehow, Michael threw the can so that it traveled on the exact same trajectory it had in the first pass. It leaves the top of the frame for maybe an instant and then drops down perfectly into the other Michael's hand. No further work was required. It was 'The Miracle Beer Can Toss'- and it probably saved us ten thousand dollars."

The ninety-six-day shoot wrapped on January 24, with the uniquely collaborative effort marking a positive experience for all concerned. "It was a production that was too good to be true," asserted Richard Edlund. "It had a long shooting schedule, but we came in on time. Whitney White and Mike Haley were terrific in dealing with the rehearsals and performances and cues and getting all of the subtle timings together. Everybody on the team- the grips, the gaffers, the technicians- anticipated everyone else's needs. It was like a great jazz group playing together."

With the multifarious visual effects so competently managed, Ramis was able to focus more fully on his job as director. "The effects element of the film was not particularly difficult because that was where we put all our time and energy," Ramis observed. "People focused their attentions on those problems for months, preparing for every complicated shot. Richard Edlund tested and retested the technology. What was tougher for me as a director was the stuff we couldn't prepare for- the psychological component of getting performances from people, working with actors. There are so many variables, and you've got mood and personality working, too; so it is not just pure creative discussion. How do I insinuate my ideas without dominating or manipulating the actor? How do I make the actor feel that his ideas have been recognized and honored? That is the tension for me every day."

Ramis' responsibilities toward Multiplicity did not end with the successful wrapping of principal photography. Still ahead was the postproduction phase, during which the digital artists at Boss

would transform rough composites into final shots. One of the problems encountered during post ministrations was graininess that developed as a result of the high-speed film stock used to shoot both effects and live-action footage, necessitating computer generated techniques to pull mattes. “Even with a sharp edge and greenscreen behind the image,” said Samuels, “the edges were unsatisfactory. We did anything and everything we could think of to solve the problem. We used all kinds of image processing tricks, from blurring in a rotomatte to rotoing sections, smoothing them as much as possible. We had no single technique- we started with the easy ones and worked up to the hard ones.”

The motion control system so essential to the reality of the composite shots also necessitated some adjustments during postproduction. “It took a lot of coordination,” said Samuels. “In many cases, the camera had been pointing from far left and swung around to the far right- with a greenscreen cart in the middle where the two characters crossed. Everything was in motion. On top of that, three of the sets had wooden floors; and with the heavy equipment flying around on them, when you looked at it on a split you could see a wobble. We had to correct all that positional deviation in the plates.”

Other shots were augmented using a variety of 3-D techniques. For example, the coffee spewing from Doug’s mouth during a particularly hectic interaction with his clones disappeared because a greenscreen was situated next to him during shooting. The spew was computer generated during postproduction by way of particle system software. In another shot, Keaton played with a paddle ball on a string- again filmed in front of a greenscreen- that disappeared completely because of motion blur. The ball and string were computer generated using Wavefront software that had been modified somewhat to serve Boss Film’s specific needs. Further tweaking by the CG department included rotoscoping elements such as shadows and reflections into the shots.

“One thing that’s different about Boss Film,”

Samuels commented, “is that we assign people shots that they see through from beginning to end. It isn’t a factory where you’ve got one person who makes the computer models, another person who lights them, and still another who does the compositing. A single individual will cover all those areas. Of course, some people do some things better than others- and if a



Leaving the clones in charge of his life while he goes off on a sailing trip, Doug returns home to learn that, due to their actions, he has been fired from his job and his wife has left him. For a scene in which Doug confronts all three clones in his living room, Keaton was again photographed in multiple passes, with small, portable greenscreens positioned around the set to accommodate the matting process. Boss Film’s on-set digital compositing system generated temp composites and split-screens for prompt viewing and evaluation by the actor and director.



At film’s end, Two, Three and Four set out to make their own lives, leaving Doug to his. Throughout the production, it was Michael Keaton’s dexterity as an actor, in tandem with Boss Film’s technical wizardry, that resulted in the near-seamless illusion of four distinct characters played by the same performer.

technical director needs help rotoing something really fine, for instance, an artist that is gifted in that area will help him out. But, basically, the shot is his baby. I think we get better work out of people because there's a lot of personal pride in their work."

"The person doing the shot does a much better job if he's in control of the whole thing," concurred effects line producer Karin Joy. "And each individual brings something different to the table. If you break a shot down into different categories, it takes the creative vision away. You might as well be making transformers in a factory."

Ron Simonson and the imaging department worked in concert with the technical direction team, and were responsible for matching and color correcting the film clips provided by the production. For each shot, the negative was scanned into the computer, after which Simonson and crew produced a series of color wedges. Once a color wedge was approved, the digitized images were brought on-line and the technical directors began working on the eyeline composite. Depending on the complexity of the shot, this procedure could take two or three days. While this was underway, the imaging department created a series of contrast and color wedges that were filmed out and then examined- a task that required one to three weeks to accomplish. The images were color corrected, then returned to the technical directors. The animating, rendering and compositing time varied significantly, depending on whether the shot was something as simple as a split or as complicated as a series of cuts requiring articulate roto and matte work. At times, tracking was also necessary to stabilize mismatched plates. After the TDs solved all of the basic compositing problems, they forwarded their work to Simonson, who used the composited images to produce a final color wedge.

While effects shots typically remain on screen no longer than five seconds, the shot lengths in *Multiplicity* ranged from twenty-five seconds to more than a minute. Computer processing time varied considerably, with the digital compositing of an average frame requiring between five and fifteen minutes. "Because we were working at film resolution," noted Samuels, "things got pretty intense. A major shot might have as many as eleven hundred frames- and at fifteen minutes per frame, we had to distribute them throughout our entire rendering system. That meant that every shot got composited on several machines simultaneously."

Simple changes to a composite meant doubling the already exhaustive work efforts. "Sometimes production would ask us for an adjustment after viewing the final composite," recalled Karin Joy. "They might ask for a reduction in the contrast, for example. I'm sure they thought 'change the contrast' meant something as simple as ordering a reprint; but it really meant going back in and redoing the color wedge. That could take a couple of days. Then the technical director would get a printout of this new information and apply it to the composite so that the lighting matched the original workprint. It was very precise, and time consuming."

With *Multiplicity*, Harold Ramis had, once again, affectionately reflected modern humanity in all its fragility and humor. "Multiplicity is funny," Ramis commented, "but it's also very affecting. You really care about Doug and each of the clones- they are not just there for comic relief. You're also moved by Doug's relationships. When he reconciles with his wife at the end of the movie and says good-bye to the clones, it is emotionally affecting- especially for a high-concept

farce. You really feel that the clones and Doug have bonded, that they are like brothers. I think the movie works on both of those levels- and I love that combination."

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